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(54) METHOD AND APPARATUS FOR RESERVING RESOURCES OF ONE OR MORE MULTIPLE ACCESS COMMUNICATION CHANNELS

VERFAHREN UND GERÄT ZUM RESERVIEREN VON MITTELN EINES ODER MEHRERER MEHRFACHZUGRIFFSKOMMUNIKATIONSKANÄLE

PROCEDE ET APPAREIL POUR LA RESERVATION DE RESSOURCES D'UNE OU PLUSIEURS VOIES DE COMMUNICATION A ACCES MULTIPLES

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Description

Field of the Invention

[0001] The present invention relates to communication networks, such as hybrid fiber coaxial (HFC) cable networks, wireless communication networks, satellite networks, etc., in which multiple subscriber stations transmit messages on one or more unidirectional multiple access communication channels. In particular, the present invention relates to enabling each subscriber station to reserve a portion of one or more multiple access unidirectional communication channels for contention free access. This enables the cable network to be used for point-to-point and multicast communication in addition to conventional broadcast TV.

Background of the Invention

[0002] It is desirable to provide ubiquitous, integrated high speed and high capacity digital communication services (such as video, data and voice) to homes, schools, governments, and businesses. One such network, the telephone network, could be upgraded to provide such services. However, the century-old copper telephone network, primarily designed for telephony, has a usable bandwidth of only about 1 MHZ. Therefore, it is quite difficult and expensive to provide multi-channel digital video, along with data and voice on the telephone network. On the other hand, the coaxial drop line of a cable network to each home has a high usable bandwidth of about 1 GHz, providing ample speed and capacity to the integrated broadband services listed above, in addition to delivering traditional broadcast analog video programs. These traditional coaxial cable networks can be readily upgraded to bidirectional hybrid fiber-coaxial cable networks (HFC networks) to enable bidirectional high speed and high capacity communications. The HFC network is inherently a shared medium technology. Nevertheless, providing efficient, high speed, high capacity shared access to the upstream transmission has been a challenge to the communication industries.

[0003] FIG 1 shows a conventional bidirectional hybrid fiber coaxial (HFC) cable network 10 having a head end 12. The head end 12 has a head end controller 28 that can communicate with one or more other networks 30, such as the Internet and local area networks. Downstream directed signals are transmitted from, and upstream directed signals are received at, the head end controller 28 via a coaxial link 34 connected to a diplexer 32. The diplexer 32 splits the downstream directed signals from the other signal carried on the link 34 and outputs them to a laser transmitter 36. The laser transmitter 36 modulates the downstream directed signals onto an optical signal that is transmitted via a downstream optical fiber trunk 14. Likewise, upstream directed signals modulated on a signal carried via an upstream optical fiber trunk 14' may be demodulated at an optical receiver 38. The diplexer 32 combines such upstream directed signals with the other signals carried on the link 34 for receipt at the head end controller 28.

[0004] The upstream and downstream optical trunks 14, 14' connect the head end 12 to an optical node 16. The head end 12 and optical node 16 may be separated by up to about 80 kilometers. Like the head end 12, the optical node 16 has a laser transmitter 40, an optical receiver 42 and a diplexer 44. The laser transmitter 40 is for modulating upstream directed signals received via the diplexer 44 onto an optical signal for transmission on the upstream directed optical trunk 14'. The optical receiver 42 is for demodulating downstream directed signals from the optical signal carried on downstream optical trunk 14 and transferring the demodulated downstream directed signal to the diplexer 44.

[0005] The diplexer 44 outputs onto coaxial trunk 18 the downstream directed signals that are demodulated by the optical receiver. Likewise, the diplexer 44 receives from the coaxial trunk 1 8 upstream directed signals for modulation by the laser transmitter 40. The individual links of the coaxial trunk 18 are interconnected by bidirectional amplifiers 20 and taps 22. Taps 22 are also provided for connecting coaxial drop lines 22 to the coaxial trunk 18. The coaxial drop lines 22 connect the subscriber locations 26 to the coaxial trunk 18 for upstream and downstream directed communication.

[0006] The optical trunks 14, 14', coaxial trunks 18, taps 20 and coaxial drop lines 22 define a shared communications medium over which communicated signals are transmitted or received by all connected network devices, such as subscriber stations at the subscriber locations 26 and the head end 12. The cable network 10 is specifically designed to deliver information in the downstream direction from the head end 12 to the subscriber locations 26. For downstream directed communication, frequency division multiplexed communication channels are defined which have mutually unique carrier frequencies and non-overlapping bands (6 MHZ bands in North America and other NTSC cable TV systems, 8 MHZ bands in Europe and other PAL and SECAM cable TV systems) in the band from 54 MHZ up to the upper cut-off frequency of the coaxial trunks 18 and drop lines 22 (typically, 500-750 MHZ). This is also known as sub-split cable network. Each 6 MHZ downstream channel can carry either traditional analog NTSC composite video signals or digitally encoded data appropriately modulated by a RF carrier. Each traditional broadcast video programs are each transmitted in a separate communication channel by modulating an NTSC signal onto a predetermined carrier signal having an assigned carrier frequency and transmitting the signal from the head end controller 28.

[0007] Although the cable network 10 has a large amount of bandwidth, the cable network 10 presents certain challenges for providing high speed and high capacity upstream transmission from a large number (typically a few hundred) of subscriber locations 26. Most notably,

the subscriber locations 26 may be distributed over a large geographic area. The signal path (i.e., sum of the lengths of the coaxial drop lines 22, coaxial trunk links 18 and optical trunk links 14) between individual subscriber locations 26 or subscriber locations 26 and the cable head end 12 can be on the order of tens of kilometers. Such long signal paths introduce noticeable delays in the transmission of signals which tend to be about 5μs/kilometer.

[0008] Recognizing such challenges, several standard bodies and industry consortiums, such as IEEE 802.14, SCTE, MCNS and DAVIC have proposed similar communication schemes as follows. Two channels are defined for communication, namely, an upstream directed channel (UC) and a downstream directed channel (DC). Subscriber stations (SSs) 50 (FIG 2), such as cable modems, set top boxes or data terminals, at subscriber locations 26 can transmit on the upstream directed channel UC but can only receive on the downstream directed channel DC. The head end 12 can only receive on the upstream directed channel UC and only transmit on the downstream directed channel DC. In other words, the upstream channel UC is a multi-point to point channel whereas the downstream channel DC is a point to multipoint channel. These channels UC and DC are said to be multiple access channels, meaning that multiple network devices (SSs 50, head end 12, etc.) are permitted to access each channel UC or DC. As such, although the physical topology of the cable network 10 is a tree and branch configuration, the communication channels UC and DC may be illustrated as a logical bus network as shown in FIG 2.

[0009] Each channel UC and DC is assigned a different frequency band and center frequency, such as is shown in FIG 3. As shown, the upstream channel UC may be assigned a band in the 5-42 MHZ band not already used for control message communication. The downstream channel DC may be assigned one of the unused 6 MHZ bands, i.e., not currently used for communicating traditional broadcast video programming. The DC channel is divided into time slots and the UC channel is divided time slots ("slots") and mini-time slots ("mini-slots"). Point-to-point or multicast communication is achieved by reading packets from, or writing packets into, the slots and mini-slots in a time division multiplexing or time division multiple access fashion. (Herein, a "packet" is an organization of a bitstream into discrete units. A packet may include control or overhead information, typically located in a header section of the packet, and user message or user data information in a "payload" section of the packet. The term "payload" is used herein more generally to refer to a channel for carrying communicated data or messages.) In order to read a packet from a channel, the particular channel is tuned (the frequency band of that channel is filtered out of the signals carried on the shared medium), and a packet is demodulated from a respective slot or mini-slot time period of the carrier signal. Likewise, in writing a packet to a channel, a packet is modulated onto a carrier signal of that channel and the modulated carrier signal is transmitted at the appropriate slot or mini-slot time period of the carrier signal and combined with the other signals carried on the shared medium.

[0010] It should be noted that the cabling distance (i.e., signal path) between any two SSs 50 and the head end 12 or the mutual cabling distance between any two SSs 50 can widely vary in the cable network 10. As such, a wide disparity of propagation delays may be incurred by each signal transmitted to or from an SS 50 depending on its relative distance to the head end 12. Assuming that the SSs 50 are synchronized to a system clock at the head end 12 using a time-stamping technique (to be detailed later), a packet transmitted at "the same time" from different SSs 50 will arrive at the head end 12 at different times. The difference can be on the order to tens of μsec. If not properly compensated, a large guard time must be inserted between each packet transmission, resulting in a very inefficient time division multiplexing (TDM) transmission in the upstream channels. To overcome this problem, the following procedure, which is generally known, will be described. Each SS 50 is polled and transmits a signal to the head end 12. The head end 12 records the propagation delay of each SS 50. The head end 12 then informs each SS 50 of how long a propagation delay is incurred by signals transmitted from that specific SS 50 to the head end 12. Each SS 50 is also informed of the maximum propagation delay of all SSs 50 in the cable network 10. Whenever a SS 50 decides to transmit a signal, the SS 50 determines the slot or mini-slot boundary at which it desires to write its packet. The SS 50 then delays its transmission from the slot or mini-slot boundary for a certain time period equal to the difference between the propagation delay of the transmitting SS 50 and the maximum propagation delay in the cable network 10. The net effect is that all signals received at the head end 12 "appear" to incur the same propagation delay as the SS 50 that incurs the maximum propagation delay.

[0011] Each SS 50 is assigned a unique identifier or address. Each packet written into each slot contains at least the address of the destination, i.e., the SS 50, which is the ultimate intended recipient of the packet. A SS 50 transmits information to another SS 50 or to the head end 12 by dividing the information into packets and writing the packets into allocated slots of the upstream channel UC. Such packets are broadcasted by the upstream channel UC to the head end 12 which reads each packet from each time slot. The head end 12 examines the destination address in the header of the packet. The head end 12 writes the packet into an available slot of the downstream channel DC. The packets are broadcasted in the downstream channel DC and are read from the slots by each SS 50. Each SS 50 compares the destination address of the received packets to its assigned address or to the group (multicast) addresses assigned to the multicast groups to which the SS 50 has subscribed. If the addresses match, the packet is accepted. Otherwise, the packet is discarded.

[0012] As will be described in greater detail below, two types of packets are transmitted in the channels UC and DC, namely, "payload" packets and "control" packets. Payload packets carry user messages or user data to be communicated to a destination. Control packets carry control messages for allocating portions of the communication channels or other overhead control information. For reasons described below, SSs 50 write control packets into mini-slots of the upstream channel UC and write payload packets into slots of the upstream channel UC. The head end 12 writes payload and control packets into slots of the downstream channel DC. For example, each slot of the downstream channel DC accepts a frame which includes one payload packet and one control packet. This is possible because only the head end 12 writes control and payload packets into slots of the downstream channel DC.

[0013] Some manner must be provided to prevent each SS 50 from attempting to write packets into the same time slot of the upstream channel UC. To that end, a slot assignment-reservation protocol is implemented according to which each SS 50 may only write packets into slots that have been assigned to that SS 50. Each SS 50 can attempt to reserve slots (i.e., request an assignment of one or more slots) by writing a reservation request control packet into a mini-slot of the upstream channel UC allocated for receiving new reservation request packets. The reservation request control packet may indicate the address or identifier of the SS, the number or size of slots needed for the to-be-communicated payload packets, (conventionally, the slot length may be an integral number of mini-slot lengths and thus the number of slots needed may be expressed as the number of "mini-slot" lengths needed), the type of the communication for which slots are requested and an error check sequence (e.g., a cyclical redundancy check or CRC). The head end 12 receives the reservation request control packets from the mini-slots and responds by assigning one or more slots to each requesting SS 50. The head end 12 then writes control packets into slots of the downstream channel DC indicating which slots were assigned to each SS 50. Each SS 50 receives control packets that respond to its respective reservation request and then transmits its payload packets only in its assigned slots. Because SS's 50 only transmit payload packets in their assigned slots, no other SS 50 contends to simultaneously access the same slot. Contention is therefore localized to relatively small size reservation mini slots, and not the relatively lengthy payload packets. Consider that each slot or mini-slot accessed by more than one SS 50 simultaneously (thereby resulting in a collision) is wasted. As such, the use of mini-slots enables the SSs 50 to obtain access to the larger slots in a fashion that conserves the bandwidth.

[0014] The payload packets are received at the head end 12. The head end 12 identifies each received payload packet destined to a SS 50 in the cable network 10, and writes each of the identified packets into an available slot of the downstream channel DC. Each SS 50 receives from the downstream channel the payload packets destined thereto.

[0015] Nevertheless, contention exists in accessing the mini-slots. Such contention is resolved using a feedback mechanism and a collision resolution algorithm (CRA). The head end 12 monitors each mini-slot and determines if a collision has occurred. If the head end 12 detects a collision, the head end 12 transmits a message via the downstream channel DC indicating in which slots a collision was detected. Each SS 50 that has attempted to transmit a reservation request packet monitors the messages transmitted in the downstream channel DC. If an SS 50 receives a message from the head end 12 indicating that a collision has occurred in the same mini-slot in which the SS 50 had previously attempted to write its reservation request packet, the SS 50 determines that its reservation request packet had collided with another transmission by another device and therefore was not received by the head end 12. In such a case, the SS 50 executes a CRA to determine whether and when to attempt to retransmit its reservation request packet. Several CRA's are known such as "ternary tree," and "P-persistent and DQRAP." See P. Jacquet, P. Muhlethaler & P. Robert, *Asymptotic Average Access Delay Analysis: Adaptive P-Persistence Versus Tree Algorithm*, IEEE P802.14, Doc. no. IEEE 802.14-96/248 (1996), and U.S. Patent No. 5, 390,181.

[0016] It is desirable to reduce contention to increase the utilization of the bandwidth in the upstream and downstream channels UC and DC and, at the same time, accommodate as large a number of SSs 50 as possible. Generally, this is achieved by increasing the ratio of mini-slots to payload slots in the upstream channel UC and decreasing the size of the mini-slots in the upstream channel UC. U.S. Patent Nos. 5,012, 469 and 5,390,181 describe different variations in the ratio and arrangement of mini-slots to payload slots in the upstream channel UC. The upstream spectrum 5-42 MHZ of a sub-split HFC cable network is susceptible to noises and interference that can limit the amount of spectrum available for reliable transmissions. The noises are, most notably, "ingress noise" and "impulse noise." Ingress noise occurs because the coaxial cabling of the trunks 18 and drop lines 22, with imperfect shielding due to corroded connectors, cracked sheath, etc., function as antennas. Different radio transmissions are picked up by the shared medium, such as citizen band (CB) radio broadcasts at around 24 MHZ, short wave radio transmissions at various points in the 5-42 MHZ band, etc., and contribute to ingress noise. Impulse noise, on the other hand, results from noise spikes that occur from other phenomenon such as lightning strikes of the coaxial cabling. The coaxial cabling of the trunks 18 may also carry an electrical power signal for supplying power to the various devices (e.g., amplifiers 20) of the cable network. Power line arching through weak points of the cables and connectors also contribute to the impulse noise.

[0017] In order to reliably transmit control packets, such as reservation request packets, in mini-slots, a binary phase shift keying (BPSK) modulation technique or quaternary phase shift keying (QPSK) modulation technique is often used. On the other hand, to maximize the amount of data transmitted in payload packets, a high order quadrature amplitude modulation (QAM) technique such as 16-QAM, 64-QAM or even 256 QAM, with powerful forward error correction (FEC) is often used. However, spectral efficient modulation schemes, such as 16-QAM, 64-QAM and 256-QAM, require longer preambles for carrier recovery and burst synchronization and incur a much higher per burst overhead for mini-slots. That is, each SS 50 actually writes a frame into each mini-slot time period, including an inter-burst guard time period and a preamble, that precede the actual mini-slot control packet, such as is shown in FIG 4. (FIG 4 also shows the mini-slot packet structure as including an address or identifier, payload packet or communication type indicator, number of requested mini-slots field and CRC field.) The devices of the cable network 10 may use raised cosine filters. Such filters introduce a ringing into the channel. In addition, transmitters and receivers of the SSs 50 and head end 12 need a finite amount of time to turn on and off in order to read and write packets into specified slots. The purpose of the guard time period is to provide sufficient time for the ringing to dampen and to enable the transmitter or receiver circuitry of the SSs 50 and head end 12 to turn on or off. Following the guard time period is a "burst" or combination of a preamble and modulated data. The purpose of the preamble is to enable a receiver to fine tune to the carrier frequency of the carrier signal on which the data is modulated and to align in phase to the carrier signal, prior to sampling the carrier signal and demodulating data from the carrier signal. This synchronization and alignment operation is referred to as "burst sync." Longer preambles are required when spectral efficient, higher order QAM schemes are used to ensure very fine tuning thereby ensuring highly accurate sampling and demodulation. The impact of such effects on mini-slot efficiency are more pronounced as the order of the QAM increases, as depicted in FIG 5. That is, a larger percentage of the time of the upstream channel UC is allocated to mini-slots as the order of the QAM increases.

[0018] To increase the utilization of the upstream channel UC, a technique of varying the time division pattern of the upstream channel UC into mini-slots and slots has also been proposed. This is illustrated in FIG 6. At the top of FIG 6, a fixed time division pattern of the upstream channel UC into slots and mini-slots is shown. The disadvantage of this technique is that much of the upstream channel UC capacity must be allocated to mini-slots to account for a typical worst case, or heavy load (numerous attempts to access mini-slots), scenario. In the alternative conventional technique, the ratio of mini-slots to slots can be dynamically varied by rearranging the pattern according to which the upstream channel is time divided into slots and mini-slots. This is depicted at the bottom of FIG 6. For example, when the load is anticipated to be light (few attempts to access mini-slots), the ratio of mini-slots to slots is reduced. When the load is anticipated to be heavy, the ratio of mini-slots to slots is increased. However, this technique has the following disadvantages:

(1) It is complex to implement.

(2) It is difficult and imprecise to predict the load based on past history, thereby risking a potential stability problem.

(3) It imposes additional constraints on the mini-slot, such as requiring that slots lengths be equal to an integral multiple of mini-slot lengths, further reducing the utilization of the upstream channel UC for payload data.

[0019] Although prior art (including those proposed in the emerging standards, such as IEEE 802.14, SCTE, MCNS and DAVIC may include multiple upstream channel support, each upstream channel is statically assigned to the station and each channel is still required to support both the control and payload bitstreams. Such a network still exhibits the inefficiency, high network latency and large delay of a single upstream channel.

[0020] U.S. Patent No. 5,278,833 describes a wireless network including a base station and "communication units," such as cellular or cordless phones. This patent describes the circuitry and communication formats in detail. Therefore, only certain details of this wireless communication system are repeated herein. A frequency division multiplexing technique is used to form two channels, namely, an upstream channel having a first band, and a downstream channel, having a second, non-overlapping band. As above, the upstream channel is used for transmitting information from the communication units to the base station and the downstream channel is for communicating information from the base station to the communication units.

[0021] Like the cable network 10, a time division multiplexing technique is used to divide each of the upstream and downstream channels into time slots. Each of the time slots may be assigned by the base station for communication between a selected communication unit and the base station. Unlike the cable network 10, the upstream channel is divided only into uniform sized time slots. However, whenever a time slot of the upstream channel is not used for ordinary payload communication, it can be divided into two or more equally sized sub-slots for transmitting control information. A communication unit can communicate by transmitting a request packet in one of the sub-slots of a time slot not previously assigned for payload communication. The base station receives such request packets, determines how many time slots are necessary for the communication unit to communicate, and transmits a control packet in a time slot of the downstream channel indicating which slots are assigned to the communication unit. The communication unit then

transmits its packets in its assigned time slot. No contention resolution protocol is specified for transmitting reservation requests. Nor does this patent explain how a communication unit determines that a time slot of the upstream channel is not assigned for payload communication. Finally, note that the upstream channel cannot carry both reservation request packets and payload packets simultaneously. The upstream channel capacity is therefore allocated to each of these kinds of packets thereby reducing the utilization of the upstream channel for carrying payload information.

[0022] U.S. Patent No. 5,012,469 discloses a satellite communications network. The satellite communications network includes plural earth stations that communicate with a satellite station. The communication is bidirectional using a single contentious channel. The channel is time division multiplexed according to one of a number of different formats depending on the traffic load. According to one format, under certain circumstances, the channel is divided into "large slots" which include one payload time slot and a fixed number of mini-slots. Each mini-slot is uniquely assigned to the earth stations for writing reservation request packets (requesting reservation of payload time slots) for transmission to the satellite station. Under other circumstances, the channel is divided into payload time slots only, and the payload time slots are uniquely assigned to each earth station. As circumstances, such as the traffic load, change, the channel is formatted according to the appropriate one of the two formats. According to a second format, the channel is formatted in one of three different ways, including the two formats mentioned above and a third format in which the channel is divided into time slots which are accessed by the earth stations in a contentious fashion. Again, the channel is formatted according to one of the three different formats depending on the circumstances. In addition to the disadvantages mentioned above for the wireless and cable networks, the architecture suggested in this patent is highly complex.

[0023] U.S. Patent No. 5,590,131 discloses a queueing random access method for the medium access control layer in networks with broadcast channels, for conserving reservation bandwith and concomitantly providing immediate transmission access, wherein, prior to receiving a first time slot, a plurality of reservation slots parameters are initialized by a user. Furthermore, it disclosed in U.S. Patent No. 5,590,131 that a reservation channel may be multiplexed with the transmission channel either in time, frequency, or space.

[0024] Scientific publication "A protocol for Efficient Transfer of Data over Fiber/Cable Systems", IEEE 1996, J.O.Limb, D.Sala, discloses a station enabled to transmit data in the shared medium of a HFC system where slots of an upstream control channel are multiplexed in time with slots of an upstream payload channel. Reservation requests are sent an said upstream control channel and in response to them assignment of slots in said upstream payload channel are received via the downstream channel. However, the access to the upstream control channel is merely based on pure contention rendering it inefficient.

[0025] It is an object of the present invention to overcome the disadvantages of the prior art.

Summary of the Invention

[0026] This and other objects are achieved by the present invention. Illustrative environments of use of the present invention are a wireless network, a satellite network, a cable network, etc. In a cable network, a head end is provided as a central controller, a shared medium is provided and multiple stations, namely, subscriber stations, are connected to the head end via the shared medium. Illustratively, the head end transmits one or more traditional broadcast video programs by modulating them onto one or more carrier signals and transmitting the carrier signals on the shared medium. Such traditional broadcast programs may thus be contemporaneously received at each subscriber station. Frequency bands not used for traditional broadcast video programming are assigned for providing point-to-point or multicast communication.

[0027] To provide such point-to-point or multicast communication, according to the invention, three types of communication channels, namely, one or more upstream payload channels, one or more upstream control channels and one or more downstream channels, are allocated. Illustratively, the carrier signal of the channels furthermore have mutually non-overlapping bands. Each bitstream is furthermore illustratively organized into packets.

[0028] The multiple access network can be formed by assigning the channels with channel identifiers and complete descriptions of the channel profiles, such as carrier frequencies, symbol rates, burst parameters, etc., so that the stations and central controller can communicate. Together with a network ID, a network configuration control message is transmitted by the central controller to all the stations attached to the medium. A minimum of three channels are needed to define the network (DCPC, UCC and UPC). Additional channels can be added to the network by the central controller. Any change in configuration is communicated to the stations using network configuration messages. Further, all control messages to the stations are uniquely identified by the network ID, channel ID, station ID and mini-slot ID, allowing flexibility to either increase or decrease the network capacity and performance according to the needs of the network service providers.

[0029] Each channel illustratively is divided into slots or mini-slots. Each upstream payload channel is assigned for carrying upstream directed payload bitstreams from the stations to the central controller. Each upstream control channel is assigned for carrying upstream directed control bitstreams, such as reservation request bitstreams requesting reservation of time slots of the up-

stream payload channel, from the stations to the central controller. Each downstream channel is assigned for carrying at least downstream directed control bitstreams, such as bitstreams containing acknowledgments and also containing indications of assigned slots in the upstream payload channel, from the central controller to the stations. Each downstream channel illustratively also carries the collision status of collided reservation request mini-slots. The downstream channel may also illustratively carry payload bitstreams.

[0030] Illustratively, stations may write reservation request bitstreams into mini-slots of the upstream control channel. Such reservation request bitstreams are received by the central controller, which responds by assigning specific slots to each station. The central controller writes control bitstreams in the downstream channel indicating the slot assignment which are received by the respective stations that issued the reservation request bitstreams. Each station then writes its payload bitstreams only in assigned slots of the upstream payload channel. Illustratively, the payload bitstreams are received by the central controller. If the received payload bitstreams are destined to a station in the network, the central controller writes such payload bitstreams into slots of the downstream channel. Each station receives the payload bitstreams transmitted in the downstream channel, accepts the bitstreams destined thereto, and discards each other payload bitstream.

[0031] According to the invention as defined in the independent method claim 1 and in the independent circuit claim 40, a station communicates on a shared medium of a network as follows. The station waits until a bitstream is received from the downstream channel indicating the identity of an available group of one or more reservation slots in the upstreams control channel, if data is available for transmission from the station, it is randomly determined, based on the indicated available group of reservation slots, whether or not to transmits a bitstream containing a request to reserve one or more slots of an upstream payload channel on an upstream control channel, but only during one of said reservation slots of the indicated group of reservation slots. The station then receives multiple bitstreams from a downstream channel, including at least one bitstream containing an indication of one or more slots of the upstream payload channel assigned to the station for transmitting packets. The station then transmits payload bitstreams on the upstream payload channel, but only at the assigned slots of the upstream payload channel. The reservation request bitstream and the payload bitstreams may be carried simultaneously on the upstream control channel and the upstream payload channel of the shared medium during overlapping time periods, or, further, reservation request and payload packets may not be transmitted simultaneously but sequentially, since they may be transmitted by a single upstream programmable RF transmitter. If reservation request and payload packets are transmitted sequentially, a first switch switches between forwarding modulated UPC and UCC signals to a single frequency agile tuner, while a second switch switches between forwarding an indication of the selected carrier signal f2 and f3, respectively.

[0032] According to the invention, as defined in the independent method claim 26 and in the independent circuit claim 54, a central controller of a network enables communication of bitstreams from a station via a shared medium of the network as follows. The central network controller receives from an upstream control channel, a reservation request bitstream, requesting reservation of slots for a particular station. The central network controller transmits on a downstream channel, a bitstream including an indication of one or more slots assigned to the particular station, and, further, the central network controller transmits on the downstream channel a bitstream including an indication of the occurence of a group of one or more available slots on the upstream control channel. The central network controller receives a bitstream from one of the assigned slots of an upstream payload channel. Again, the reservation request bitstreams and the payload bitstreams may be carried simultaneously on the upstream control channel and the upstream payload channel of the shared medium during overlapping time periods, or, further, reservation request and payload packets may not be transmitted simultaneously but sequentially, since they may be transmitted by a single upstream programmable RF transmitter. If reservation request and payload packets are transmitted sequentially, a first switch switches between forwarding modulated UPC and UCC signals to a single frequency agile tuner, while a second switch switches between forwarding an indication of the selected carrier signal f2 and f3, respectively.

[0033] Further preferred embodiments of the invention are defined in the dependent claims.

[0034] By transmitting reservation request packets and upstream directed payload packets on separate "simultaneous" channels, each channel can be utilized to its fullest potential. For example, different modulation techniques can be used on each channel, such as BPSK, QPSK, n-QAM, orthogonal frequency division multiplexing (OFDM), discrete multi-tone modulation (DMT), discrete wavelet multi-tone modulation (DWMT), code division multiple access (CDMA), synchronous code division multiple access (SCDMA), etc. This maximizes efficiency of the upstream payload channel yet ensures high reliability and short mini-slot size on the upstream control channel. By reducing the mini-slot size, the likelihood of collision on the upstream control channel decreases, and retransmission delays in the event of collisions can be overall reduced (depending on the collision resolution technique utilized). Likewise, by removing mini-slots from the upstream payload channel, the channel utilization for payload packets is maximized, even while using higher spectral efficiency modulation techniques. Thus, the competing demands of reservation request packets and payload packets can be satisfied without detriment to

each other.

[0035] The multiple access method can simplify multiple channel support for expanded bandwidth demand and can maximize the number of supported subscriber stations. To increase the capacity, each upstream payload channel or each downstream payload channel can be added to the network. To minimize contention and lower the access delay of the multiple access network, the stream of mini-slots in the upstream control channel can be enhanced by allocating a wider bandwidth, or assigning some subscriber stations to different upstream control channels.

Brief Description of the Drawing

[0036]

FIG 1 shows a conventional HFC cable network.
FIG 2 shows a conventional logical bus assignment of channels in a HFC cable network.
FIG 3 shows a conventional allocation of carrier frequencies and bands to channels.
FIG 4 shows a conventional mini-slot frame.
FIG 5 shows a conventional division of an upstream channel into slots and mini-slots using different modulation techniques.
FIG 6 shows conventional fixed and dynamic patterns for dividing the upstream channel into slots and mini-slots.
FIG 7 shows a logical bus network according to the present invention.
FIG 8 shows an allocation of frequencies to channels according to an embodiment of the present invention.
FIG 9 shows upstream control channel UCC and upstream payload channel streams according to an embodiment of the present invention.
FIG 10A shows circuitry in a subscriber station according to an embodiment of the present invention.
FIG 10B shows circuitry in an upstream RF transmitter according to another embodiment of the present invention.
FIG 11 shows an illustrative packet structure for packets transmitted in the downstream channel for use in the circuitry of FIGs 10A and 10B.
FIGs 12-13 show a flow chart of a process executed by a subscriber station according to an embodiment of the present invention.
FIG 14 shows circuitry in a head end according to an embodiment of the present invention.
FIG 15 shows a flow chart of a process executed by a head end according to an embodiment of the present invention.
FIG 16 shows a graph comparing payload efficiency of the present invention to the prior art.

Detailed Description of the Invention

[0037] The present invention may be implemented in any kind of network, such as a wireless network, a satellite network, a cable network, etc. For sake of convenience, this invention is illustrated in detail for a two way HFC cable network (HFC network) having a tree and branch physical topology, similar to the conventional topology shown in FIG 1. As such, the present invention is readily usable with existing cable networks with limited modification for two-way operation. In this illustration, the central controller is the head end, the stations are the subscriber stations and the shared medium is the optical fiber and coaxial cabling that connects the head end, fiber nodes and subscriber stations.

[0038] According to the invention, three types of communication channels are provided (in addition to the other channels for carrying traditionally broadcast programs in the downstream direction). The three types of communication channels are a downstream control and payload channel DCPC, an upstream control channel UCC and an upstream payload channel UPC. At least one of each type of the three channels described is needed for the communication network in this invention. A logical network configuration according to the present invention is shown in FIG 7. In one embodiment (e.g., FIG 10A), the upstream control channel UCC and the upstream payload channel UPC can carry bitstreams from a single SS simultaneously. That is, different bitstreams may be simultaneously carried on the upstream payload channel UPC and the upstream control channel UCC during overlapping periods of time. Such "simultaneous" channels can be defined using a number of modulation techniques such as FDM, OFDM, DMT, DWMT, CDM, FM, etc. For sake of illustration this invention is illustrated using an FDM technique wherein each of the three communication channels DCPC, UPC and UCC has a unique carrier frequency, f1, f2 or f3, respectively, and mutually non-overlapping bands, as shown in FIG 8. For example, the UCC and UPC channel bands are located between 5 and 42 MHZ whereas the DCPC channel band is between 54 and the upper cut-off frequency of the cable network (typically 750 MHZ, but can be as high as 1 GHZ). Each downstream channel, including the downstream control and payload channels DCPC are allocated bands in units of 6 MHZ (in North America, according to NTSC TV channel convention). The upstream channels, including the upstream control channel UCC and the upstream payload channel UPC are allocated bands of various bandwidths, typically from 100 KHz to 6 MHZ, wherever a low noise sub-band in the band from 5-42 MHZ can be found.

[0039] Referring again to FIG 7, the downstream control and payload channel DCPC serves the same purpose as the downstream channel DC in FIG 2 and is divided into slots. The upstream control channel UCC is divided into mini-slots only for carrying control packets such as reservation request packets. On the other hand, the UPC is divided into slots only for carrying payload packets. As

before, SSs 150 can write in one of the designated slots according to a retransmission rule of the upstream channels UPC and UCC and can only read packets from the slots of the downstream control and payload channel DCPC. Likewise, the head end 112 can only write packets in the slots of the downstream control and payload channel DCPC and can only read packets from the slots and mini-slots of the upstream channels UPC and UCC. Furthermore, the SSs 150 can write packets only in assigned slots of the upstream payload channel UPC. The SSs 150 can also freely write packets in mini-slots of the upstream control channel UCC, designated according to a retransmission rule, subject only to contention from the other SSs 1 50. Alternatively, the mini-slots may be accessed in a contention free manner by polling the SSs 150 or by uniquely and fixedly assigning each mini-slot to each SS 150. In yet another scheme, a mix of contentious and fixedly assigned mini-slots are provided.

[0040] Thus, unlike the channel architecture of FIGs 2 and 3, the channel architecture of FIGs 7 and 8 requires that contention free transmission of upstream directed payload packets in slots and contentious transmission of upstream directed reservation request packets in mini-slots occur in different frequency division modulated channels in different frequency bands. This is illustrated in FIG 9, wherein the upstream payload channel UPC carries a stream of only payload packets in slots (which may be fixed or variable in size). Simultaneously, the upstream control channel UCC carries a stream of only reservation request packets in mini-slots (which illustratively are of a fixed size). As such, in one illustrative embodiment (e.g., in the circuitry of FIG 10A, to be described in greater detail below), both kinds of transmissions can occur simultaneously, without interfering with each other or otherwise constraining each other. For instance, the packets transmitted on the upstream payload channel UPC may be n-QAM (where n = 16, 64, 256,...), QPSK, etc., modulated and the packets transmitted on the upstream control channel UCC may be BPSK, QPSK, ... etc. modulated. As such, the mini-slot frames may begin with relatively shorter preambles (not shown). Each control packet written in a mini-slot frame may include a subscriber station address or identifier, an identifier of the type of communication for which the slot(s) is (are) requested, the size or number of slots requested and other information (e.g., error check and/or correction codes or sequences, etc.).

[0041] FIG 10A shows the circuitry in a subscriber station 150 used to adapt the subscriber station 150 according to one embodiment of the invention. FIG 10A does not show conventional circuitry which also may be present in a subscriber station 150 for receiving traditional broadcast channels, for transmitting requests to receive pay-per view events, for processing data, for receiving and digitizing voice or video, etc. The coaxial drop line 22 is connected to a diplexer 152. The diplexer 152 separates the downstream receive channel bands from the upstream transmit channel bands. The downstream channel signals, including the downstream control and payload channel DCPC signal, are outputted to a downstream RF receiver 154. Likewise, the upstream control channel and upstream payload channel signals (if any are present) outputted from the upstream RF transmitters 156 are combined by the diplexer 152 for output onto the coaxial drop line 22.

[0042] The received signals outputted from the diplexer 152 to the downstream RF receiver 154 are inputted to a frequency agile tuner 158. As shown, the frequency agile tuner 158 receives a signal indicating the carrier frequency (or center frequency) selection of f1 and channel bandwidth thereby causing the frequency agile tuner 158 to filter out only the downstream control and payload channel DCPC frequency band.

[0043] The filtered out downstream control and payload channel DCPC signal is inputted to a receiver/demodulator, forward error corrector, deinterleaver and decoder 160. The receiver circuit 176 performs the inverse functions of the transmitter circuit 260 (see FIG 14). Illustratively, some of these subcircuits are optional and are merely included for sake of illustration. See ITU-T Recommendation J.83, Digital Multi-Programme Systems for Television Sound and Data Services for Cable Distribution, Oct., 1995. The circuit 160 includes a receiver/demodulator which receives and demodulates the packet data from the carrier signal (or signals) assigned to the downstream control and payload channel DCPC. Such received packets are outputted to a subscriber media access control circuit 162.

[0044] The subscriber media access control circuit 162 outputs payload packets and reservation request packets at the appropriate time to the upstream RF transmitters 156. Payload packets are received at an encoder, interleaver, forward error corrector and modulator 176. The forward error corrector adds forward error correction bits to the packet data. The modulator modulates the packet onto a carrier signal, e.g., using a QPSK modulation technique, a 16, 64 or 256-QAM modulation technique, etc. The modulated carrier signal is outputted to a frequency agile tuner 178. The frequency agile tuner 178 also receives an indication of the carrier signal or center frequency f2 and bandwidth assigned to the upstream payload channel UPC. In response, the frequency agile tuner 178 shifts the modulated carrier signal to the band assigned to the upstream payload channel UPC. Illustratively, the indication of the frequency can be varied to change the frequency band to which the frequency agile tuner 178 shifts the modulated signal e.g., to avoid noisy portions of the 5-42 MHZ band.

[0045] The reservation request packets are outputted from the subscriber media access controller 162 to an encoder and modulator 182. The encoder subcircuit of the circuit 182 may perform a different encoding than the encoder subcircuit of the circuit 176 performs, which different encoding is appropriate for the particular modulation technique employed in the modulator 182. Illustratively, the modulator 182 modulates the reservation re-

quest packet using a BPSK or QPSK modulation technique. The modulated signal is outputted to frequency agile tuner 184. As shown, the frequency agile tuner 184 receives an indication of the frequency f3 assigned to the upstream control channel UCC. As such, the frequency agile tuner 184 shifts the modulated signal to the frequency band assigned to the upstream control channel UCC. Like the frequency agile tuner 178, the indication of the frequency can be varied so that the frequency agile tuner 184 shifts the modulated signal to a selectable frequency band.

[0046] The modulated carrier signals for the upstream payload channel UPC and the upstream control channel UCC are inputted to an RF amplifier 180. The RF amplifier 180 outputs the amplified upstream payload channel UPC and upstream control channel UCC signals to the diplexer 152. The diplexer 152 outputs the upstream payload channel UPC and upstream control channel UCC signal onto the coaxial drop line 22 for transmission to the head end 112 (FIG 7).

[0047] The filtered out downstream control and payload channel DCPC signal is inputted to a demodulator, forward error corrector, deinterleaver and decoder 160. Illustratively, not all of these subcircuits are needed to implement the invention. The circuit 160 includes a demodulator/ receiver which demodulates the packet data from the carrier signal (or signals) assigned to the downstream control and payload channel DCPC.

[0048] The subscriber media access controller 162 may be implemented using one or more integrated circuit chips. The subscriber media access control circuit 162 can be implemented using a programmable processor or a finite state automata. Below, the subscriber media access control circuit 162 is described as containing several subcircuits for sake of convenience.

[0049] FIG 10B shows an alternative embodiment upstream RF transmitters 156. Specifically, single upstream RF programmable transmitter 356 is shown, which may be used in subscriber station 150 of FIG 10A. Illustratively, single upstream RF programmable transmitter may be implemented from a commercially available transmitter chip, such as the STEL 1109.

[0050] Similar to the description of FIG 10A, the subscriber media access control circuit 162 outputs payload packets and reservation request packets at the appropriate time to the single upstream RF transmitter 356. Payload packets are received at a UPC burst profile circuit 376, while control packets are received at a UCC burst profile circuit 382. Each burst profile circuit includes parameter pertaining to the symbol rate, the modulation, the burst preamble (such as the length and pattern of the burst), error checking and/or forward error-correcting code (FEC), and an inter-burst guardband to account for the timing skew, ramping up and down of the transmitter. Transmitter 356 also includes a carrier frequency selection circuit 385 which outputs either a payload carrier frequency selection f2 or a control carrier frequency selection f3. In addition, transmitter 356 includes first and second switches 310 and 315, respectively. First switch 310 is coupled between burst profile circuits 376, 382 and a frequency agile tuner 390. Second switch 315 is coupled between carrier frequency selection circuit 385 and tuner 390. Tuner 390 is also coupled to RF amplifier 380, that is similar to RF amplifier 180 in FIG 10A.

[0051] In operation, when an upstream payload bitstream is received from subscriber media access control circuit 162, it is supplied to UPC burst profile circuit 376. The UPC burst profile circuit processes the bitstream according to its parameters. For example, using FEC parameters, the burst profile circuit adds forward error correction bits to the packet data. Further, using modulation parameters, the burst profile circuit modulates the packet onto a carrier signal. The modulated carrier signal is then outputted to frequency agile tuner 390, via switch 310. Simultaneously, the frequency agile tuner also receives an indication of the carrier signal or center frequency f2 and bandwidth assigned to the upstream payload channel UPC from carrier frequency selection circuit 385, via switch 315. In response, the frequency agile tuner 378 shifts the modulated carrier signal to the band assigned to the upstream payload channel UPC. Illustratively, the indication of the frequency can be varied to change the frequency band to which the frequency agile tuner 178 shifts the modulated signal e.g., to avoid noisy portions of the 5-42 MHZ band.

[0052] The reservation request (control) packets are outputted from the subscriber media access controller 162 to UCC burst profile circuit 382. As with UPC burst profile circuit 376, the UCC burst profile circuit processes and modulates the bitstream according to its parameters. The modulated carrier signal is then outputted to frequency agile tuner 390, via switch 310. Simultaneously, the frequency agile tuner also receives an indication of the carrier signal or center frequency f3 and bandwidth assigned to the upstream payload channel UCC from carrier frequency selection circuit 385, via switch 315. In response, the frequency agile tuner 378 shifts the modulated carrier signal to the band assigned to the upstream payload channel UCC.

[0053] The modulated carrier signals for the upstream payload channel UPC and the upstream control channel UCC are inputted to RF amplifier 380. The RF amplifier 380 outputs the amplified upstream payload channel UPC and upstream control channel UCC signals to the diplexer 152. The diplexer 152 outputs the upstream payload channel UPC and upstream control channel UCC signal onto the coaxial drop line 22 for transmission to the head end 112. However, unlike the transmitter of FIG 10A, due to the inherent time delay that the embodiment of FIG 10B incurs (due to the channel switching delay of switches 310 and 315), the head end may take such delay into account when scheduling and granting the reservation or payload burst transmission.

[0054] Illustratively, packets received from the downstream control and payload channel are MPEG-2 transport stream packets into which other message packets,

packet fragments or cells may be inserted, such as is shown in FIG 11. According to the MPEG-2 systems standard, each transport packet is 188 bytes long with a four byte header and a 184 byte message carrying portion (commonly referred to as "payload" which should be distinguished from the usage of the term payload herein). The MPEG-2 transport stream packet includes a synchronization word and a 1 3-bit packet identifier or "PID." Other control information is also present in the transport stream packet header. A group of reserved PIDs will be used by circuit 162 to separate the MPEG-2 payloads (carrying digital video programs) from other types of control and data (such as Internet packet segments, ATM cells or STM bitstreams).

[0055] The message carrying portion of the packet includes, illustratively, two types of packets, namely, a "control" packet and a "payload" packet. The downstream control demultiplexer 166, demultiplexes the control packet. The control packet includes a network configuration message which contains a network ID, the DCPC channel ID, the UCC channel ID and the UPC channel ID that together defines the multiple access network. Additional channel IDs may also be included as needed. All necessary channel information and parameters needed to configure the station transmitters and receivers are broadcasted to all stations using additional control messages. The station will transmit its upstream packets using the pre-configured channels.

[0056] The station monitors the control messages from the central controller. The mini-slot collision status feedback control message will uniquely identify the status of mini-slot transmission by using the network ID, UCC channel ID and mini-slot ID. Likewise, the bandwidth reservation grants, transmitted to the station, are uniquely identified by the network ID, a per-grant station ID (which includes an address or identifier of the destination station), while the granted time slots the payload transmission are uniquely identified by the UPC channel ID, start of mini-slot ID and number of slots granted. One or more grants can be sent within grant message. In addition, the control packet may include other control information.

[0057] As shown in FIG 11, the bandwidth reservation grant field may include in each reservation grants, #1 to #N, an ID of the subscriber station receiving the reservation grant, a UPC channel ID, a transmit start mini-slot ID field and a number of slots granted field. The UPC channel ID includes an address or identifier of the destination SS. The subscriber media access controller 162 determines whether or not the address in this ID field matches the address of the SS 150 in which the subscriber media access controller 162 resides or a multicast address of a multicast group to which this SS 1 50 has subscribed. If not, the control information in the transmit start slot ID field and number of slots granted field are destined to another SS and this information is discarded. If the addresses match, the information in the transmit start slot ID field and number of slots granted field is destined to the SS 150 in which the subscriber media access controller 162 is located and the information is processed as described below.

[0058] The downstream payload demultiplexer 164 demultiplexes and reassembles the packet data in the payload packet. The payload packet may contain messages, Internet packet segments, a synchronous transfer mode (STM) bitstream, asynchronous transfer mode (ATM) cells, etc. Using header information in the payload packet, the subscriber media access controller 162 determines whether the payload packet data is destined to the SS 150 in which the subscriber access media controller 162 resides, and therefore should be accepted, or whether the payload packet data is destined to another SS and should be discarded.

[0059] Referring back to FIG 10A, the subscriber media access controller 162 also includes a transmit scheduler 168, a retransmission rule decision circuit 170, an upstream payload multiplexer 172 and a reservation request packet generator 174. The operation of the circuits 168, 170, 172 and 174 are now described with reference to FIGs 12-13. In a first step S1, the transmission scheduler 168 performs certain initialization procedures. For instance, the transmission scheduler 168 receives from the control packets indications of available mini-slots, assigned slots and other information regarding timing. (The additional information may be a uniform system time clock maintained by the head end 112 which periodically transmits packets containing "snapshots" of the system time clock (time stamps) to the SSs 150. For example, the technique used in MPEG-2 systems for reestablishing the system time clock using program clock references or PCR's may be used to synchronize the SS clock to the head end clock. See ISO/IEC 13818-1: Generic Coding of Moving Pictures and Associated Audio, Part 1: Systems.) In a next step S2, the transmit scheduler 168 determines whether or not a pending queue (not shown) contains payload data waiting for transmission. If not, step S1 is repeated. If to-be-transmitted payload data is available, in step S3, the transmit scheduler 168 determines how much capacity is necessary to transmit the to-be-transmitted data (e.g., in terms of the number of mini-slot time periods, if slot sizes are allocated in such increments). Next, in step S4, the transmit scheduler 168 determines the next available mini-slot in which a reservation request packet may be transmitted. For example, the control packets demultiplexed from the downstream control and payload channel DCPC include a start mini-slot identification indication and an indication of the number of mini-slots, in a group of mini-slots, beginning with the identified start mini-slot that are available for new reservation request packets. The start of the mini-slot boundary can be specified by an offset counter referenced to a synchronized timing marker at the head end 112 and at each SS 150. According to one technique, the transmit scheduler 168 generates a random number and determines whether or not the random number falls within the range of 1 to the number indicated as being in the group of available mini-slots. If not, the transmit

scheduler 168 refrains from transmitting reservation request packets until a control message is received from the head end 112 indicating the next available group of mini-slots.

[0060] On the other hand, if the random number falls within the range, then, in step S5, the transmit scheduler 168, at the appropriate time, provides an indication of the needed slot capacity to the reservation request packet generator 174. In response, the reservation request packet generator 174 generates a reservation request packet including the address or identifier of the SS 150, the requested slot capacity and the type of communication data to be communicated in the requested slots. The reservation request packet generator 174 is activated by the transmit scheduler 168 so as to output the reservation request packet at the specified time for transmission in the upstream control channel at the particular mini-slot, of the next group of available mini-slots, indicated by the random number generated by the transmit scheduler 168. (The actual transmission time of the request packet may be delayed from the time of the leading boundary of the corresponding mini-slot in which the reservation request packet is transmitted. The delay time may be the difference between the SS to head end propagation delay time at this particular SS 1 50 and the maximum SS to head end propagation delay time.) The net result is that mini-slot bursts from all SSs will arrive at the head end controller receiver tuners 258, 259 with minimum skew. Next, in step S6, the reservation request packet generator 174 then signals the retransmission rule decision circuit 170 to set its acknowledgment timer and begin counting. The retransmission rule decision circuit 170 responds by setting an appropriate timer and counting down the timer. The timer is illustratively set to expire after a time period exceeding the worst case feedback delay, equal to the round-trip propagation delay plus the processing delay at the head end 112 and SS 150, between transmitting reservation request packets and receiving acknowledgment packets in response. In step S7, the retransmission rule decision circuit 170 waits for an acknowledgment control packet to be received by the downstream payload demultiplexer 164. The retransmission rule decision circuit 170 responds to one of the following events:

(1) The timer expires (step S8). Illustratively, this indicates that the reservation request message was not received. In response, the retransmission rule decision circuit 170 causes the transmit scheduler 168 to schedule the reservation request packet generator 174 to retransmit the reservation request packet at the next available mini-slot of the upstream control channel UCC. This is achieved by step S9 which causes execution to return to step S4.

(2) Before the timer expires, a message is received from the head end 112 via the downstream control and payload channel DCPC indicating that a collision has occurred (steps S9-S11). For example, such an indication may be present in the mini-slot collision status field of a control packet received on the downstream control and payload channel DCPC (FIG 12). In response, in step S12, the retransmission rule decision circuit 170 updates its collision resolution algorithm parameters (e.g., the persistent parameter, the next available collision resolution mini-slot, etc.) The retransmission rule decision circuit 170 furthermore determines whether or not to reattempt to transmit the reservation request packet. Assuming the retransmission rule decision circuit 170 determines to reattempt transmission, the transmission rule decision circuit 170 determines when to perform such a retransmission in step S13 and schedules the retransmission in step S14. At the appropriate time, steps S17, S5-S7 are performed whereby the transmit scheduler 168 causes the reservation request packet generator 174 to regenerate the reservation request packet and retransmit it at the next available mini-slot on the upstream control channel UCC available for collided reservation request packets. This also causes the retransmission rule decision circuit 170 to stop the timer (step S9).

(3) Before the timer expires, a message is received in a control packet transmitted from the head end 112 via the downstream control and payload channel DCPC acknowledging receipt of the reservation request packet but indicating that no slots are currently available for assignment (steps S9-S11, S13). Illustratively, this causes the retransmission rule decision circuit 170 to stop the timer (step S9) and wait for the grant control message indicating which slots are assigned to the SS 150 (step S15).

(4) Before the timer expires, a message is received in a control packet transmitted from the head end 112 via the downstream control and payload channel DCPC acknowledging receipt of the reservation request packet and assigning specific slots for transmission (steps S9, S15). For example, such information may be present in the transmit start slot ID and number of granted slots fields of a received control packet (FIG 11). This also causes the retransmission rule decision circuit 170 to stop the timer (step S9).

[0061] In response to receiving a grant control packet that assigns one or more slots to the SS 150, the transmit scheduler 168 schedules the pending to-be-transmitted data residing in the queue for transmission in step S15. At the appropriate time, the data is segmented into packets by the upstream payload multiplexer 172 and outputted to the encoder, interleaver, forward error corrector and modulator circuit 176, under control of the transmit scheduler 168. The transmit scheduler uses the internal system clock, the start slot indication and number of granted slot indications received in control packets by the downstream control demultiplexer 166 to properly synchronize the segmentation and modulation of packet

data with the assigned slot(s). (Again, the actual transmission may be delayed from the leading slot boundary by a particular delay equal to the difference between the head end 112 to SS 150 propagation delay for this SS 150 and the maximum head end 112 to SS propagation delay.) Afterwards, in step S 16, an accounting is made of the remaining to-be-transmitted data in the queue and processing returns to step S1.

[0062] Referring now to FIG 14, a circuit for adapting a head end controller of a head end 112 is shown. The head end 112 has a downstream RF transmitter 256, an upstream payload channel RF receiver 254 and an upstream control channel RF receiver 255. The downstream RF transmitter 256 receives packets at an encoder, interleaver, forward error corrector and modulator circuit 260. This circuit 260, amongst other things, modulates packets onto a carrier signal for transmission. The modulated carrier signal is outputted to a frequency agile tuner 278 which also receives an indication of the carrier or center frequency f1. The frequency agile tuner 278 shifts the modulated carrier signal to the downstream control and payload channel DCPC band. The RF amplifier 280 amplifies the signal and outputs the amplified signal to diplexer 252. Diplexer 252 combines the downstream control and payload channel signal thus generated with the other signals carried on coaxial link 34.

[0063] The diplexer 252 also splits off the upstream directed signals 253 from the signals carried on the coaxial link 34. The upstream payload channel RF receiver 254 has a frequency agile tuner 258 that receives the upstream directed signals, an indication of the carrier or center frequency f2 and an indication of the bandwidth of the upstream payload channel UPC. As such, the frequency agile tuner 258 filters out the upstream payload channel UPC signal. The filtered out upstream payload UPC channel signal is inputted to a burst demodulator, forward error corrector and decoder circuit 276. Amongst other things, the circuit 276 demodulates and receives each payload packet from the upstream payload channel UPC and outputs each payload packet to the head end media access controller 262.

[0064] Likewise, the upstream control channel RF receiver 255 has a frequency agile tuner 259 that receives the upstream directed signals outputted from the diplexer 252, an indication of the carrier or center frequency f3 and an indication of the bandwidth of the upstream control channel UCC. As such, the frequency agile tuner 259 filters out the upstream control channel UCC signal. The filtered-out signal is inputted to a burst demodulator and decoder circuit 282. Amongst other things, the circuit 282 demodulates each control packet from the upstream control channel UCC and outputs each control packet to the collision detector 290. As shown, the collision detector 290 is connected to a reservation request register 292 and a mini-slot collision status queue 294. In response to detecting a collision, collision status information is inputted to the collision status register 294. In response to receiving a reservation request packet, information regarding the reservation request, e.g., the address of the requesting SS, the amount of requested slot capacity, etc., is stored in the reservation request register 292.

[0065] The head end media access controller 262 is shown as including an upstream synchronizer 230, a resource allocator 232, a contention resolution circuit 234 and a packet filter and forward circuit 236. While shown as separate circuits, the head end media access controller 262 can also be implemented with a suitably programmed processor.

[0066] The purpose of the packet filter and forward circuit 236 is to receive payload packets from within the cable network and from other networks 230 and to forward such packets to the correct destination. Packets destined outside of the cable network are transmitted to one of the other attached networks 30. Packets destined to a SS 150 are enqueued in downstream transmitted data buffer 240 for transmission on the payload bitstreams of downstream control and payload channel DCPC.

[0067] The purpose of the upstream synchronizer 230 is to maintain a system clock and to periodically broadcast time stamps of the system clock to the SSs 150 so that all station system clocks and the head end system clock are synchronized. Once synchronized, station MACs 162 will know the precise mini-slot location by referencing the offset value to the time-stamp value broadcasted down the DCPC. The upstream synchronizer 230 also synchronizes the transmission of packets on the downstream control and payload channel DCPC. In addition, several different kinds of packets may be available for transmission in the downstream transmitter data buffer 240 which may be stored in separate queues. The upstream synchronizer 230 judiciously selects from amongst the different types of enqueued packets depending on their type and their respective urgency for output from the downstream transmitter data buffer 240. As noted above, the packets transmitted on the downstream control and payload channel DCPC may be MPEG-2 transport stream packets containing specific PIDs, control packets and payload packets. The upstream synchronizer 230 segments enqueued packets and reassembles them into MPEG-2 transport stream packets as necessary. However, this is only illustrative; other multiplexing and encoding schemes can be used.

[0068] The purpose of the resource allocator 232 is to keep track of resources and allocate them in a fair and orderly manner or according to the priority of each communication for which resources are allocated. Most notably, the resource allocator 232 keeps track of allocated slots on the upstream payload channel UPC and ensures that each slot is allocated only to a single SS 150. The allocation technique employed by the resource allocator 232 can be quite intricate wherein slots are allocated on a prioritized basis depending on the type of communication for which each SS 150 has requested to reserve slots.

[0069] The purpose of the contention resolution circuit

234 is to generate a control packet message when a collision occurs. The contention resolution circuit 234 may also maintain statistics on the number of collisions, which statistics may in turn be used to control when to broadcast a start available mini-slot for new reservation requests or how many mini-slots to make available in a group of mini-slots for new reservation requests. The contention resolution circuit 234 therefore controls how many residual mini-slots are available for retransmitting collided reservation request packets.

[0070] The slot allocation operation of the head end circuitry 112 will now be described with reference to FIG 15. In step S20, the upstream control channel RF receiver 255 receives a modulated signal from the upstream control channel and demodulates a reservation request control packet therefrom. In step S21, the collision detection circuit 290 receives a reservation request packet from the upstream control channel RF receiver 255. Next, the collision detector determines whether or not a collision has occurred, e.g., by performing an error check on the received reservation request packet. In step S22, the collision detection circuit 290 updates the collision status register to indicate whether or not a collision has occurred. In step S23, if a collision has occurred, then in step S24, the contention resolution circuit 234 updates various contention resolution parameters (e.g., number of collisions, etc.). The contention resolution circuit 234 furthermore enqueues a collision detected control packet into the downstream transmitter data buffer 240. In step S25, the collision detected control packet is outputted to the downstream RF transmitter 256 for transmission at the appropriate time slot of the downstream control and payload channel DCPC under the control of the upstream synchronizer 230. Processing then returns to step S20.

[0071] In step S23, if no collision has occurred then the resource allocator 232 determines whether or not sufficient resources (e.g., slots of the upstream payload channel UPC) are available for allocating slots to the requesting SS 150 (step S26). If not, then in step S27 the resource allocator 234 notes the request as pending and generates a grant pending acknowledgment control packet which is enqueued in the downstream transmitter data buffer 240. The grant pending acknowledgment control packet is outputted to the downstream RF transmitter 256 for transmission at the appropriate time slot of the downstream control and payload channel DCPC under the control of the upstream synchronizer 230. Processing then returns to step S20.

[0072] If in step S26, the resource allocator 234 determines that sufficient resources are available for satisfying the reservation request, then processing proceeds to step S28. In step S28, the resource allocator 234 assigns resources, i.e., slots, to the SS 150 that transmitted the reservation request. The resource allocator 234 then generates a slot assignment acknowledgment control packet indicating the slots which were assigned to the requesting SS 150. As noted above, such a packet includes the identifier or address of the requesting SS 150, the identifier of the starting slot in the upstream payload channel UPC assigned to the requesting SS 150 and the slot capacity (e.g., measured by the number of mini-slot lengths of the assigned slot) assigned to the SS 1 50. The resource allocator 234 enqueues the slot assignment acknowledgment control packet thus generated in the downstream transmitter data buffer 240. The slot assignment acknowledgment control packet is outputted to the downstream RF transmitter 256 for transmission at the appropriate time slot of the downstream control and payload channel DCPC under the control of the upstream synchronizer 230. Processing then returns to step S20.

[0073] FIG 16 shows a graph of payload efficiency for the present invention and the prior art. As shown, as higher order QAM techniques are used, a larger fraction of the communication bandwidth is allocated for mini-slots in the prior art. In contrast, according to the invention, all of the bandwidth in the upstream payload channel UPC is allocated for payload packets. Thus, no reduction in bandwidth occurs as higher order QAM techniques are employed. Other advantages achieved by the invention include:

(1) Because the upstream control and payload bitstreams are separated into different channels, each channel can be individually optimized for the best mode of operation. For example, the upstream control channel, requiring relatively low bit rate and short mini-slot bursts, is best served by a robust modulation scheme with relatively narrow bandwidth that can be fit into the available narrow "gap" in the upstream spectrum with ingress noise. This preserves the wider available low noise bandwidth spectrum for upstream payload channels, which requires optimization for the highest efficiency with longer payload bursts.

(2) Note also that it is easier to increase the payload capacity by simply adding upstream payload channels. The head end does not need equipment for such added upstream payload channels that can distinguish control information (i.e., mini-slot boundaries and contents) from payload information (i.e., slot boundaries and contents) for such added channels as in the conventional system. Similar reasoning applies to adding additional upstream control channels to accommodate additional subscriber stations. Thus, the inventive system is easier to expand.

(3) No complex system reconfiguration algorithm for repeatedly time dividing each upstream channel into both slots and mini-slots is needed. Thus, system robustness increases. This results, because subscriber stations need not periodically reconfigure the time division of the upstream channels to optimize channel utilization. Frequent reconfigurations will increase the probabilities of erroneous configuration of each subscriber station. Because such reconfigurations are not performed, the likelihood of erroneous reconfiguration by a subscriber station is de-

creased. In addition, less overhead in the downstream control and payload channel will be achieved because there is no need for frequent sending of reconfiguration messages down to the stations.

(4) The modulation technique for each of the upstream control and payload channels may be independently selected to optimize the robustness or information carrying capacity of that channel, simplifying the introduction of advanced modulation technologies.

[0074] As noted above, the implementation of the invention in a cable network was merely illustrative. The invention may for instance be employed in a wireless network. In this case, the central controller is a base station, the subscriber stations are communication units such as cordless or cellular telephones or terminals and the shared medium is the air. The transmitters and receivers of the central controller and the communication units interface to the shared medium using radio antennae. Note that the subscriber stations may be stationary or mobile within the coverage area of the base station.

[0075] In another embodiment, the invention is employed in a satellite communication system. The central controller is a satellite, e.g., in geosynchronous orbit, the subscriber stations are earth stations and the shared medium is the air and space. The satellite includes a transponder and on-board controller. The transmitters and receivers of the earth stations and the transponder of the satellite interface with the shared medium using antennae.

[0076] As further noted above, different modulation techniques may be employed to achieve the upstream control and upstream payload channels that can simultaneously carry information. Some modulation schemes are single carrier modulation schemes such as QPSK and n-QAM. Other modulation schemes utilize multiple carriers, such as DMT, DWMT and OFDM. According to one technique, the upstream control and payload channels are defined using FDM and SCDMA. According to such a definition, each channel is defined by one or more "orthogonal" code sequences. The sequences assigned to all of the channels are then modulated onto a single carrier across the bandwidth of the entire FDM channel.

[0077] The above discussion is intended to be illustrative of the invention. Those having ordinary skill in the art may devise numerous alternative variations of the invention without departing from the scope of the following claims.

Claims

1. A method for enabling a station (150) to communicate via a shared medium of a network comprising the steps of:

   (a) transmitting on an upstream control channel (f3) a reservation request bitstream containing a request to reserve one or more slots of an upstream payload channel (f2),
   (b) receiving a plurality of bitstreams from a downstream channel (f1), including at least one bitstream containing an indication of one or more slots of said upstream payload channel (f2) assigned to said station for transmitting payload bitstreams, and
   (c) transmitting said payload bitstreams on said payload channel (f2), only at said assigned slots of said upstream payload channel (f2); said method **characterised by** comprising the further steps of:
   (d) prior to step (a), waiting until a bitstream is received from said downstream channel (f1) indicating the identity of an available group of one or more reservation slots in said upstream control channel (f3),
   (e) if data is available for transmission from said station, randomly determining, based on said indicated available group of reservation slots, whether or not to perform step (a), but only during one of said reservation slots of said indicated group of reservation slots.

2. The method of claim 1, wherein said reservation request bitstream and said payload bitstreams are carried simultaneously on said upstream control channel (f3) and said upstream payload channel (f2) of said shared medium during overlapping time periods.

3. The method of claim 1, wherein said reservation request bitstream and said payload bitstreams are sequentially transmitted by switching between transmitting said reservation request bitstream and the payload bitstreams.

4. The method of claim 2 or claim 3, further comprising the steps of:

   (f) after beginning to perform step (a), receiving from said downstream channel (f1) a bitstream indicating that a collision occurred in said upstream control channel (f3) in performing said step (a), and
   (g) in response, retransmitting said reservation request bitstream.

5. The method of claim 2 or claim 3, further comprising the steps of:

   (f) after performing step (a) but before step (b), setting an acknowledgment timer, and
   (g) response to said acknowledgment timer expiring before receiving a bitstream containing an acknowledgment from said downstream chan-

nel (f1), repeating step (a).

6. The method of claim 5 further comprising the steps of:

(h) after performing step (f), but before performing step (g), receiving said bitstream from said downstream channel (f1) containing an acknowledgment of receipt of said reservation request but also indicating that no slots in said upstream payload channel are available for allocation, and
(i) refraining from repeating step (a) in said step (g).

7. The method of claim 2 or claim 3, further comprising the step of:

(f) receiving from said downstream channel (f2) a payload bitstream containing a communicated message originating from another station in said network.

8. The method of claim 2 or claim 3, wherein each of said bitstreams received from said downstream channel are organized into MPEG-2 transport packets.

9. The method of claim 2 or claim 3, wherein said upstream control channel (f3), said upstream payload channel (f2) and said downstream channel (f1) each have a mutually different frequency band.

10. The method of claim 2 or claim 3, wherein said network is a cable network, said station (150) is a subscriber station (150) and said shared medium includes cabling.

11. The method of claim 2 or claim 3 wherein said network is a wireless network, said station is a communication unit and said shared medium is the air.

12. The method of claim 2 or claim 3, wherein said network is a satellite network, said station is an earth station and said shared medium comprises the air and space.

13. The method of claim 2 or claim 3, wherein said downstream channel (f1) is received by a plurality of stations via said shared medium.

14. The method of claim 2 or claim 3, wherein said upstream control channel (f3) and said upstream payload channel (f2) are multiple access channels.

15. The method of claim 2 or claim 3, wherein first and second modulation techniques are used for said upstream control channel (f3) and said upstream payload channel (f2), respectively, said first modulation technique optimizing the robustness of said upstream control channel (f3) without degrading the robustness or utilization of said upstream payload channel (f2).

16. The method of claim 2 or claim 3, wherein in step (a), said upstream control channel (f3) on which said bitstream containing said request is transmitted is one of plural upstream control channels (f3).

17. The method of claim 2 or claim 3, wherein in step (b), said downstream channel (f1) on which said bitstream containing said indication is received is one of plural downstream channels (f1).

18. The method of claim 2 or claim 3, wherein in step (c), said upstream payload channel (f2) on which said bitstream is transmitted is one of plural upstream payload channels (f2).

19. The method of claim 3 wherein prior to step (a), further comprising the step receiving
a bitstream indicating an identity of said multiple access network from said downstream channel (f1), wherein said identity of said network includes at least an identity of said downstream (f1) and upstream channels (f2, f3).

20. The method of any of claims 1-19, wherein each of said downstream channel (f1), said upstream payload channel (f2) and said upstream control channel (f3) has its own center frequency, bandwith and modulation scheme.

21. The method of any of claims 1-20, wherein said station is a cable modem, and wherein said shared medium is a hybrid fiber-coaxial network.

22. The method of any of claims 1-21, wherein said upstream control channel (f3) is one of a plurality of upstream control channels, and wherein said upstream payload channel (f2) is one of a plurality of upstream payload channels.

23. The method of claim 1, wherein said network further comprises a central controller, and wherein a communication between said station (150) and said controller is enabled by performing the steps (a), (b), (c), (d) and (e).

24. The method of claim 23, wherein said reservation request bitstream and said payload bitstreams are carried simultaneously on said upstream control channel (f3) and said upstream payload channel (f2) of said shared medium during overlapping time periods.

25. The method of claim 23 wherein said reservation request bitstream and said payload bitstreams are sequentially transmitted by switching between transmitting said reservation request bitstream and the payload bitstreams.

26. A method in a central controller of a network, for enabling communication of bitstreams from a particular station (150) via a shared medium of the network comprising the steps of:

(a) receiving from an upstream control channel (f3), a reservation request bitstream, requesting reservation of slots of an upstream payload channel (f2) for said particular station (150),
(b) transmitting on a downstream channel (f1), a bitstream indicating one or more slots of said upstream payload channel (f2) assigned to said particular station (150), and
(c) receiving a bitstream from said particular station on one or more of said assigned slots of an upstream payload channel (f2); said method **characterised by** comprising the further steps of:
(d) prior to step (a), transmitting on said downstream channel (f1) a bitstream including an indication of the occurrence of a group of one or more available slots on said upstream control channel (f3).

27. The method of claim 26, wherein said reservation request bitstream and said payload bitstreams are carried simultaneously on said upstream control channel (f3) and said upstream payload channel (f2) of said shared medium during overlapping time periods.

28. The method of claim 26, wherein said reservation request bitstream and said payload bitstreams are sequentially transmitted by switching between transmitting said reservation request bitstream and the payload bitstreams.

29. The method of claim 27 or claim 28, further comprising the steps of:

(e) detecting a collision during said step (a), and
(f) in response to said collision, transmitting a bitstream in said payload channel including a notification to at least said particular station (150) that said collision occurred.

30. The method of claim 27 or claim 28, further comprising the steps of:

(e) after step (a) but before step (b), in response to an absence of available slots in said upstream payload channel (f2), transmitting said bitstream on said downstream channel including an acknowledgment of receipt of said reservation request from said particular station (150) but also including an indication that no slots of said upstream payload channel (f2) are currently available for allocation.

31. The method of claim 27 or claim 28 further comprising the steps of:

(e) receiving a payload bitstream from said upstream payload channel originating from a first station (150) and destined to a second station (150), and
(f) transmitting said payload bitstream on said downstream channel (f1).

32. The method of claim 27 or claim 28 wherein said upstream control channel (f3), said upstream payload channel (f2)and said downstream channel (f1) each have a mutually different frequency band.

33. The method of claim 27 or claim 28, wherein said upstream control channel (f3) and said upstream payload channel (f2) are multiple access channels.

34. The method of claim 27 or claim 28, wherein said downstream channel (f1) is received by a plurality of stations via said shared medium.

35. The method of claim 28 wherein in step (b), each of the assigned slots being indicated by at least one of a network identifier, a station identifier, an upstream payload channel identifier and a mini-slot identifier.

36. The method of claim 28 wherein in step (d), each of said available slots being indicated by at least one of a network identifier, a station identifier, an upstream control channel identifier and a mini-slot identifier.

37. The method of claim 27, wherein first and second modulation techniques are used for said upstream control channel (f3) and said upstream payload channel (f2), respectively, said first modulation technique optimizing the robustness of said upstream control channel without degrading a robustness or utilization of said upstream payload channel (f2).

38. The method of any of claims 26-37, wherein each of said downstream channel (f1), said upstream payload channel (f2) and said upstream control channel (f3) has its own center frequency, bandwith and modulation scheme.

39. The method of any of claims 26-38, wherein said upstream control channel (f3) is one of a plurality of upstream control channels, and wherein said up-

stream payload channel (f2) is one of a plurality of upstream payload channels.

40. A circuit for enabling a station (150) to communicate via a shared medium of a network comprising:

(a) a receiver (154) for receiving a plurality of bitstreams from a downstream channel (f1), including at least one bitstream containing an indication of one or more slots of an upstream payload channel assigned to said station (150) for transmitting bitstreams,
(b) transmitting means (156, 356) for transmitting payload bitstreams on said payload channel (f2), only at said assigned slots of said upstream payload channel (f2), and for transmitting on an upstream control channel (f3) reservation request bitstreams containing a request to reserve one ore more slots of an upstream payload channel (f2); said circuit **characterised by** further comprising:
(c) a transmit scheduler (168) for waiting until said receiver (154) receives a bitstream from said downstream channel (f1) indicating the identity of an available group of one or more reservation slots in said upstream control channel (f3), and if data is available for transmission from said station, randomly determining, based on said indicated available group of reservation slots, whether or not to cause said transmitting means (156, 356) to transmit said reservation request bitstream on said upstream control channel (f3), but only during one of said reservation slots of said indicated group of reservation slots.

41. The circuit of claim 40, wherein said transmitting means (156) comprises a first transmitter (178) for transmitting said reservation request bitstreams and a second transmitter (184) for transmitting said payload bitstreams for carrying bitstreams simultaneously on said upstream control channel (f3) and said upstream payload channel (f2) of said shared medium during overlapping time periods.

42. The circuit of claim 40, wherein said transmitting means comprises a transmitter (390), and wherein said circuit comprises a first switch (310) for coupling said transmitter (390) to one of said payload bitstream and said reservation request bitstream, based on an upstream selection.

43. The circuit of claim 40 further comprising a second switch (315) for coupling a payload carrier frequency selection signal to said transmitter when said first switch (310) couples said upstream payload channel (f2) to said transmitter (390), and for coupling a control carrier frequency selection signal to said transmitter (390) when said first switch (310) couples said upstream control channel (f3) to said transmitter.

44. The circuit of claim 41 or claim 42, further comprising:

a retransmission rule decision circuit for responding to said receiver receiving from said downstream channel (f1) a bitstream containing an indication that a collision occurred in said upstream control channel (f3) by causing said transmission means (156, 356) to transmit said reservation request bitstream
onto said upstream control channel (f3) again.

45. The circuit of claim 41 or claim 42, further comprising:

retransmission rule decision circuit for setting an acknowledgment timer, after said transmission means (156, 356) transmits said reservation request bitstream on said upstream control channel (f3) and, in response to said acknowledgment timer expiring before said receiver receives (154) an bitstream containing an acknowledgment from said downstream channel (f1), causing said transmission means (156, 356) to transmit said reservation request bitstream on said upstream control channel (f3) again.

46. The circuit of claim 45 wherein after setting said timer, but before said timer expires, said receiver (154) receives a bitstream from said downstream channel (f1) containing an acknowledgment of receipt of said reservation request bitstream but also containing an indication that no slots in said upstream payload channel (f2) are available for allocation, and wherein, in response, said retransmission rule decision circuit refrains from causing said transmission means (156, 356) to transmit said reservation request bitstream on said upstream control channel (f3) again.

47. The circuit of claim 41 or claim 42, wherein said receiver (154) is adapted to receive from said downstream channel (f1) a payload bitstream containing a communicated message originating from another station (150) in said network.

48. The circuit of claim 42 wherein the receiver (154) is adapted to receive a bitstream indicating an identity of said multiple access network on said downstream channel (f1), wherein said identity of said network includes at least an identity of said downstream (f1) and upstream channels (f2, f3).

49. The circuit of claim 42 wherein the receiver (154) is adapted to receive a bitstream indicating an identity of each of the assigned upstream payload slots on said downstream channel (f1), said bitstream indi-

cating said identity based on at least one of a network identifier, a station identifier, an upstream payload channel identifier and a mini-slot identifier.

50. The circuit of claim 42 wherein the receiver (154) is adapted to receive a bitstream indicating an identity of assigned upstream reservation request slots on said downstream channel (f1), said bitstream indicating said identity based on at least one of a network identifier, a station identifier, an upstream control channel identifier and a mini-slot identifier.

51. The circuit of claim 50 wherein the receiver (154) is adapted to receive a bitstream indicating a notification to each station that a collision occurred at a particular reservation request slost on said downstream channel (f1), said bitstream indicating said notification based on at least one of said network identifier, said station identifier, said upstream control channel identifier and said mini-slot identifier.

52. The circuit of any of claims 40-51, wherein each of said downstream channel (f1), said upstream payload channel (f2) and said upstream control channel (f3) has its own center frequency, bandwith and modulation scheme.

53. The circuit of any of claims 40-52, wherein said station is a cable modem, and wherein said shared medium is a hybrid fiber-coaxial network.

54. A circuit in a central controller of a network, for enabling communication of bitstreams from a station (150) on a shared medium of the network comprising:

(a) a first receiver (255) for receiving from an upstream control channel (f3), a reservation request bitstream, requesting reservation of slots of an upstream payload channel (f2) for a particular station (150),
(b) a transmitter (256') for transmitting on a downstream channel (f1), a bitstream indicating one or more slots of said upstream payload channel (f2) assigned to said particular station (150), and
(c) a second receiver (254) for receiving a bitstream from one of said assigned slots of an upstream payload channel (f2), said circuit **characterised by** further comprising:

an upstream synchronizer for causing said transmitter (256') to transmit on said downstream channel (f1) a bitstream containing an indication of the occurrence of a group of available slots in said upstream control channel (f3).

55. The circuit of claim 54, wherein said bitstreams are carried simultaneously on said upstream control channel (f3) and said upstream payload channel (f2) of said shared medium during overlapping time periods.

56. The circuit of claim 54 further comprising:

a collision detection circuit (290) for detecting whether or not a collision occurred in said reservation request bitstream received by said first receiver (255), and in response to detecting said collision, causing said transmitter (255) to transmit a bitstream on said downstream channel (f1) containing a notification to at least said particular station (150) that said collision occurred.

57. The circuit of claim 54 further comprising:

a resource allocator for responding to said reservation request bitstream and an absence of available slots in said upstream payload channel, by causing said transmitter (256') to transmit said bitstream on said downstream channel containing an acknowledgment of receipt of said reservation request bitstream from said particular station (150) but also indicating that no slots of said upstream payload channel (f2) are currently available for allocation.

58. The circuit of claim 54 further comprising:

a downstream transmit data buffer (240) for storing a payload bitstream received by said second receiver (254) from said upstream payload channel (f2) originating from a first station (150) and destined to a second station (150), and an upstream synchronizer for causing said transmitter (256') to transmit said payload bitstream on said downstream channel (f1):

59. The circuit of any of claims 54-58, wherein each of said downstream channel (f1), said upstream payload channel (f2) and said upstream control channel (f3) has its own center frequency, bandwith and modulation scheme.

Patentansprüche

1. Verfahren zur Ermöglichung einer Station (150), über einen gemeinsamen Datenträger eines Netzwerks zu kommunizieren, umfassend folgende Schritte:

(a) Senden auf einem Upstream-Kontrollkanal (f3) eines Reservierungsanforderungs-Bitstroms, der eine Anforderung enthält, um einen

oder mehrere Abschnitte eines Upstream-Nutzlastkanals (f2) zu reservieren,

(b) Empfangen einer Vielzahl von Bitströmen aus einem Downstream-Kanal (f1), der mindestens einen Bitstrom umfasst, der eine Angabe eines oder mehrerer Abschnitte des Upstream-Nutzlastkanals (f2) enthält, die der Station zugewiesen sind, um Nutzlastbitströme zu senden, und

(c) Senden der Nutzlastbitströme auf dem Nutzlastkanal (f2), und zwar nur in den zugewiesenen Abschnitten des Upstream-Nutzlastkanals (f2); wobei das Verfahren **dadurch gekennzeichnet ist, dass** es folgende weitere Schritte umfasst:

(d) vor Schritt (a) Warten bis ein Bitstrom von dem Downstream-Kanal (f1) empfangen wurde, der die Identität einer verfügbaren Gruppe von einem oder mehreren Reservierungsabschnitten in dem Upstream-Kontrollkanal (f3) angibt,

(e) wenn Daten zum Senden von der Station verfügbar sind, auf der Basis der angegebenen verfügbaren Gruppe von Reservierungsabschnitten wahlfreies Bestimmen, ob der Schritt (a) ausgeführt wird oder nicht, aber nur während einem der Reservierungsabschnitte der angegebenen Gruppe von Reservierungsabschnitten.

2. Verfahren nach Anspruch 1, wobei der Reservierungsanforderungs-Bitstrom und die Nutzlastbitströme gleichzeitig auf dem Upstream-Kontrollkanal (f3) und dem Upstream-Nutzlastkanal (f2) des gemeinsamen Datenträgers während überlappenden Zeiträumen transportiert werden.

3. Verfahren nach Anspruch 1, wobei der Reservierungsanforderungs-Bitstrom und die Nutzlastbitströme durch Umschalten zwischen der Sendung des Reservierungsanforderungs-Bitstroms und der Nutzlastbitströme aufeinander folgend gesendet werden.

4. Verfahren nach Anspruch 2 oder Anspruch 3, ferner umfassend folgende Schritte:

(f) nach Beginn der Ausführung von Schritt (a) Empfangen eines Bitstroms aus dem Downstream-Kanal (f1), der angibt, dass bei der Ausführung von Schritt (a) eine Kollision in dem Upstream-Kontrollkanal (f3) stattgefunden hat, und

(g) als Antwort darauf erneutes Senden des Reservierungsanforderungs-Bitstroms.

5. Verfahren nach Anspruch 2 oder Anspruch 3, ferner umfassend folgende Schritte:

(f) nach Ausführen von Schritt (a), jedoch vor Schritt (b), Stellen eines Bestätigungszeitgebers, und

(g) als Antwort auf das Ablaufen des Bestätigungszeitgebers vor dem Empfang eines Bitstroms, der eine Bestätigung von dem Downstream-Kanal (f1) enthält, Wiederholen von Schritt (a).

6. Verfahren nach Anspruch 5, ferner umfassend folgende Schritte:

(h) nach Ausführen von Schritt (f), jedoch vor Ausführen von Schritt (g), Empfangen des Bitstroms aus dem Downstream-Kanal (f1), der eine Bestätigung des Empfangs der Reservierungsanforderung enthält, jedoch auch angibt, dass keine Abschnitte in dem Upstream-Nutzlastkanal für die Zuteilung verfügbar sind, und

(i) Unterlassen Schritt (a) in Schritt (g) zu wiederholen.

7. Verfahren nach Anspruch 2 oder Anspruch 3, ferner umfassend folgenden Schritt:

(f) Empfangen eines Nutzlastbitstroms aus dem Downstream-Kanal (f2), der eine übertragene Nachricht enthält, die von einer anderen Station in dem Netzwerk ausgeht.

8. Verfahren nach Anspruch 2 oder Anspruch 3, wobei jeder der Bitströme, die von dem Downstream-Kanal empfangen werden, in MPEG-2-Transportpakete geordnet ist.

9. Verfahren nach Anspruch 2 oder Anspruch 3, wobei der vorgeschaltete Kontrollkanal (f3), der vorgeschaltete Nutzlastkanal (f2) und der nachgeschaltete Kanal (f1) jeweils ein voneinander verschiedenes Frequenzband aufweisen.

10. Verfahren nach Anspruch 2 oder Anspruch 3, wobei das Netzwerk ein Kabelnetzwerk, die Station (150) eine Teilnehmerstation (150) ist und der gemeinsame Datenträger Kabel umfasst.

11. Verfahren nach Anspruch 2 oder Anspruch 3, wobei das Netzwerk ein drahtloses Netzwerk, die Station eine Kommunikationseinheit und der gemeinsame Datenträger Luft ist.

12. Verfahren nach Anspruch 2 oder Anspruch 3, wobei das Netzwerk ein Satellitennetzwerk, die Station eine Bodenstation ist und der gemeinsame Datenträger Luft und Raum umfasst.

13. Verfahren nach Anspruch 2 oder Anspruch 3, wobei der nachgeschaltete Kanal (f1) von einer Vielzahl

von Stationen über den gemeinsamen Datenträger empfangen wird.

14. Verfahren nach Anspruch 2 oder Anspruch 3, wobei der vorgeschaltete Kontrollkanal (f3) und der vorgeschaltete Nutzlastkanal (f2) Mehrfachzugriffskanäle sind.

15. Verfahren nach Anspruch 2 oder Anspruch 3, wobei erste und zweite Modulationstechniken jeweils für den Upstream-Kontrollkanal (f3) und den Upstream-Nutzlastkanal (f2) verwendet werden, wobei die erste Modulationstechnik die Robustheit des Upstream-Kontrollkanals (f3) optimiert, ohne die Robustheit oder Verwendung des Upstream-Nutzlastkanals (f2) zu beeinträchtigen.

16. Verfahren nach Anspruch 2 oder Anspruch 3, wobei in Schritt (a) der vorgeschaltete Kontrollkanal (f3), auf dem der Bitstrom, der diese Anforderung enthält, gesendet wird, einer von mehreren Upstream-Kontrollkanälen (f3) ist.

17. Verfahren nach Anspruch 2 oder Anspruch 3, wobei in Schritt (b) der nachgeschaltete Kanal (f1), auf dem der Bitstrom, der die Angabe enthält, empfangen wird, einer von mehreren Downstream-Kanälen (f1) ist.

18. Verfahren nach Anspruch 2 oder Anspruch 3, wobei in Schritt (c) der vorgeschaltete Nutzlastkanal (f2), auf dem der Bitstrom gesendet wird, einer von mehreren Upstream-Nutzlastkanälen (f2) ist.

19. Verfahren nach Anspruch 3, das vor Schritt (a) noch den Schritt des Empfangens eines Bitstroms, der eine Identität des Mehrfachzugriffsnetzwerks von dem Downstream-Kanal (f1) angibt, umfasst, wobei die Identität des Netzwerks mindestens eine Identität der Downstream- (f1) und Upstream-Kanäle (f2, f3) umfasst.

20. Verfahren nach einem der Ansprüche 1 bis 19, wobei jeder Kanal des Downstream-Kanals (f1), des Upstream-Nutzlastkanals (f2) und des Upstream-Kontrollkanals (f3) seine eigene Mittenfrequenz, Bandbreite und Modulationsmethode aufweist.

21. Verfahren nach einem der Ansprüche 1 bis 20, wobei die Station ein Kabelmodem ist, und wobei der gemeinsame Datenträger ein Hybrid-Faser-Koaxial-Netzwerk ist.

22. Verfahren nach einem der Ansprüche 1 bis 21, wobei der vorgeschaltete Kontrollkanal (f3) einer von einer Vielzahl von Upstream-Kontrollkanälen ist, und wobei der vorgeschaltete Nutzlastkanal (f2) einer von einer Vielzahl von Upstream-Nutzlastkanälen ist.

23. Verfahren nach Anspruch 1, wobei das Netzwerk ferner ein zentrales Steuergerät umfasst, und wobei eine Kommunikation zwischen der Station (150) und dem Steuergerät ermöglicht wird, indem die Schritte (a), (b), (c), (d) und (e) ausgeführt werden.

24. Verfahren nach Anspruch 23, wobei der Reservierungsanforderungs-Bitstrom und die Nutzlastbitströme gleichzeitig auf dem Upstream-Kontrollkanal (f3) und dem Upstream-Nutzlastkanal (f2) des gemeinsamen Datenträgers während überlappenden Zeiträumen transportiert werden.

25. Verfahren nach Anspruch 23, wobei der Reservierungsanforderungs-Bitstrom und die Nutzlastbitströme durch Umschalten zwischen der Sendung des Reservierungsanforderungs-Bitstroms und der Nutzlastbitströme aufeinander folgend gesendet werden.

26. Verfahren in einem zentralen Steuergerät eines Netzwerks zum Ermöglichen einer Kommunikation von Bitströmen von einer bestimmten Station (150) über einen gemeinsamen Datenträger des Netzwerks, umfassend folgende Schritte:

(a) Empfangen eines Reservierungsanforderungs-Bitstroms aus einem Upstream-Kontrollkanal (f3), der eine Reservierung von Abschnitten eines Upstream-Nutzlastkanals (f2) für die bestimmte Station (150) anfordert,
(b) Senden eines Bitstroms auf einem Downstream-Kanal (f1), der einen oder mehrere Abschnitte auf dem Upstream-Nutzlastkanal (f2) angibt, die der bestimmten Station (150) zugewiesen sind, und
(c) Empfangen eines Bitstroms von der bestimmten Station in einem oder mehreren der zugewiesenen Abschnitte eines Upstream-Nutzlastkanals (f2); wobei das Verfahren **dadurch gekennzeichnet ist, dass** es ferner folgende Schritte umfasst:
(d) vor Schritt (a) Senden eines Bitstroms auf dem Downstream-Kanal (f1), der eine Angabe des Vorkommens einer Gruppe von einem oder mehreren verfügbaren Abschnitten auf dem Upstream-Kontrollkanal (f3) umfasst.

27. Verfahren nach Anspruch 26, wobei der Reservierungsanforderungs-Bitstrom und die Nutzlastbitströme gleichzeitig auf dem Upstream-Kontrollkanal (f3) und dem Upstream-Nutzlastkanal (f2) des gemeinsamen Datenträgers während überlappenden Zeiträumen transportiert werden.

28. Verfahren nach Anspruch 26, wobei der Reservierungsanforderungs-Bitstrom und die Nutzlastbitströme durch Umschalten zwischen der Sendung des

Reservierungsanforderungs-Bitstroms und der Nutzlastbitströme aufeinander folgend gesendet werden.

29. Verfahren nach Anspruch 27 oder Anspruch 28, ferner umfassend folgende Schritte:

(e) Erfassen einer Kollision während Schritt (a), und

(f) als Antwort auf die Kollision Senden eines Bitstroms in dem Nutzlastkanal, der eine Meldung für mindestens die bestimmte Station (150) umfasst, dass die Kollision stattgefunden hat.

30. Verfahren nach Anspruch 27 oder Anspruch 28, ferner umfassend folgende Schritte:

(e) nach Schritt (a), jedoch vor Schritt (b), als Antwort auf ein Nichtvorhandensein verfügbarer Abschnitte in dem Upstream-Nutzlastkanal (f2) Senden des Bitstroms auf dem Downstream-Kanal, der eine Bestätigung des Empfangs der Reservierungsanforderung von der bestimmten Station (150) sowie eine Angabe, dass derzeit keine Abschnitte auf dem Upstream-Nutzlastkanal (f2) für die Zuteilung verfügbar sind, umfasst.

31. Verfahren nach Anspruch 27 oder Anspruch 28, ferner umfassend folgende Schritte:

(e) Empfangen eines Nutzlastbitstroms von dem Upstream-Nutzlastkanal, der von einer ersten Station (150) ausgeht und für eine zweite Station (150) bestimmt ist, und

(f) Senden des Nutzlastbitstroms auf dem Downstream-Kanal (f1).

32. Verfahren nach Anspruch 27 oder Anspruch 28, wobei der vorgeschaltete Kontrollkanal (f3), der vorgeschaltete Nutzlastkanal (f2) und der nachgeschaltete Kanal (f1) jeweils ein voneinander verschiedenes Frequenzband aufweisen.

33. Verfahren nach Anspruch 27 oder Anspruch 28, wobei der vorgeschaltete Kontrollkanal (f3) und der vorgeschaltete Nutzlastkanal (f2) Mehrfachzugriffskanäle sind.

34. Verfahren nach Anspruch 27 oder Anspruch 28, wobei der nachgeschaltete Kanal (f1) von einer Vielzahl von Stationen über den gemeinsamen Datenträger empfangen wird.

35. Verfahren nach Anspruch 28, wobei in Schritt (b) jeder der zugewiesenen Abschnitte durch mindestens einen Bezeichner eines Netzwerkbezeichners, eines Stationsbezeichners, eines Upstream-Nutzlastkanal-Bezeichners und eines Mini-Abschnitt-Bezeichners angegeben wird.

36. Verfahren nach Anspruch 28, wobei in Schritt (d) jeder der verfügbaren Abschnitte durch mindestens einen Bezeichner eines Netzwerkbezeichners, eines Stationsbezeichners, eines Upstream-Kontrollkanalbezeichners und eines Mini-Abschnitt-Bezeichners angegeben wird.

37. Verfahren nach Anspruch 27, wobei erste und zweite Modulationstechniken jeweils für den Upstream-Kontrollkanal (f3) und den Upstream-Nutzlastkanal (f2) verwendet werden, wobei die erste Modulationstechnik die Robustheit des Upstream-Kontrollkanals optimiert, ohne die Robustheit oder Verwendung des Upstream-Nutzlastkanals (f2) zu beeinträchtigen.

38. Verfahren nach einem der Ansprüche 26 bis 37, wobei jeder Kanal des Downstream-Kanals (f1), des Upstream-Nutzlastkanals (f2) und des Upstream-Kontrollkanals (f3) seine eigene Mittenfrequenz, Bandbreite und Modulationsmethode aufweist.

39. Verfahren nach einem der Ansprüche 26 bis 38, wobei der vorgeschaltete Kontrollkanal (f3) einer von einer Vielzahl von Upstream-Kontrollkanälen ist, und wobei der vorgeschaltete Nutzlastkanal (f2) einer von einer Vielzahl von Upstream-Nutzlastkanälen ist.

40. Schaltung zur Ermöglichung einer Station (150) über einen gemeinsamen Datenträger eines Netzwerks zu kommunizieren, umfassend:

(a) einen Empfänger (154) zum Empfangen einer Vielzahl von Bitströmen aus einem Downstream-Kanal (f1), die mindestens einen Bitstrom umfasst, der eine Angabe von einem oder mehreren Abschnitten eines Upstream-Nutzlastkanals enthält, die der Station (150) zum Senden von Bitströmen zugewiesen sind,

(b) Sendemittel (156, 356) zum Senden von Nutzlastbitströmen auf dem Nutzlastkanal (f2), nur in den zugewiesenen Abschnitten des Upstream-Nutzlastkanals (f2) und zum Senden von Reservierungsanforderungs-Bitströmen auf einem Upstream-Kontrollkanal (f3), die eine Anforderung enthalten, um einen oder mehrere Abschnitte auf einem Upstream-Nutzlastkanal (f2) zu reservieren; wobei die Schaltung ferner folgendes umfasst:

(c) ein Sendesteuerprogramm (168) zum Warten, bis der Empfänger (154) einen Bitstrom von dem Downstream-Kanal (f1) empfängt, der die Identität einer verfügbaren Gruppe von einem oder mehreren Reservierungsabschnitten in dem Upstream-Kontrollkanal (f3) angibt, und

wenn Daten zum Senden von der Station verfügbar sind, basierend auf der angegebenen verfügbaren Gruppe von Reservierungsabschnitten, wahlfreies Bestimmen, ob die Sendemittel (156, 356) dazu veranlasst werden sollen oder nicht, den Reservierungsanforderungs-Bitstrom auf dem Upstream-Kontrollkanal (f3) zu senden, aber nur während einer der Reservierungsabschnitte der angegebenen Gruppe von Reservierungsabschnitten.

41. Schaltung nach Anspruch 40, wobei die Sendemittel (156) einen ersten Sender (178) zum Senden der Reservierungsanforderungs-Bitströme und eine zweiten Sender (184) zum Senden der Nutzlastbitströme umfassen, um Bitströme gleichzeitig auf dem Upstream-Kontrollkanal (f3) und dem Upstream-Nutzlastkanal (f2) des gemeinsamen Datenträgers während überlappenden Zeiträumen zu transportieren.

42. Schaltung nach Anspruch 40, wobei die Sendemittel einen Sender (390) umfassen, und wobei die Schaltung einen ersten Schalter (310) zum Zusammenschalten des Senders (390) mit einem des Nutzlastbitstroms und des Reservierungsanforderungs-Bitstroms, basierend auf einer vorherigen Auswahl, umfasst.

43. Schaltung nach Anspruch 40, ferner umfassend einen zweiten Schalter (315) zum Zusammenschalten eines Nutzlast-Trägerfrequenz-Auswahlsignals mit dem Sender, wenn der erste Schalter (31) den Upstream-Nutzlastkanal (f2) mit dem Sender (390) zusammenschaltet, und zum Zusammenschalten eines Kontroll-Trägerfrequenz-Auswahlsignals mit dem Sender (390), wenn der erste Schalter (310) den Upstream-Kontrollkanal (f3) mit dem Sender zusammenschaltet.

44. Schaltung nach Anspruch 41 oder Anspruch 42, ferner umfassend:

eine Weitersenderegel-Entscheidungsschaltung, um darauf zu antworten, dass der Empfänger aus dem Downstream-Kanal (f1) einen Bitstrom empfängt, der eine Angabe enthält, dass eine Kollision in dem Upstream-Kontrollkanal (f3) stattgefunden hat, indem die Sendemittel (156, 356) dazu veranlasst werden, den Reservierungsanforderungs-Bitstrom noch einmal auf dem Upstream-Kontrollkanal (f3) zu senden.

45. Schaltung nach Anspruch 41 oder Anspruch 42, ferner umfassend:

eine Weitersenderegel-Entscheidungsschaltung, um einen Bestätigungszeitgeber zu stellen, nachdem die Sendemittel (156, 356) den Reservierungsanforderungs-Bitstrom auf dem Upstream-Kontrollkanal (f3) gesendet haben, und als Antwort darauf, dass der Bestätigungszeitgeber abläuft, bevor der Empfänger (154) einen Bitstrom empfängt, der eine Bestätigung von dem Downstream-Kanal (f1) enthält, Veranlassen der Sendemittel (156, 356), den Reservierungsanforderungs-Bitstrom noch einmal auf dem Upstream-Kontrollkanal (f3) zu senden.

46. Schaltung nach Anspruch 45, wobei nach dem Stellen des Zeitgebers, jedoch bevor der Zeitgeber abläuft, der Empfänger (154) einen Bitstrom aus dem Downstream-Kanal (f1) empfängt, der eine Empfangsbestätigung des Reservierungsanforderungs-Bitstroms sowie eine Angabe, dass in dem Upstream-Nutzlastkanal (f2) keine Abschnitte für die Zuteilung verfügbar sind, enthält, und wobei als Antwort darauf, die Weitersenderegel-Entscheidungsschaltung es unterlässt, die Sendemittel (156, 356) dazu zu veranlassen, den Reservierungsanforderungs-Bitstrom noch einmal auf dem Upstream-Kontrollkanal (f3) zu senden.

47. Schaltung nach Anspruch 41 oder Anspruch 42, wobei der Empfänger (154) dazu geeignet ist, aus dem Downstream-Kanal (f1) einen Nutzlastbitstrom zu empfangen, der eine übertragene Nachricht enthält, die von einer anderen Station (150) in dem Netzwerk ausgeht.

48. Schaltung nach Anspruch 42, wobei der Empfänger (154) dazu geeignet ist, einen Bitstrom zu empfangen, der eine Identität des Mehrfachzugriffsnetzwerks auf dem Downstream-Kanal (f1) angibt, wobei die Identität des Netzwerks mindestens eine Identität des Downstream- (f1) und der Upstream-Kanäle (f2, f3) umfasst.

49. Schaltung nach Anspruch 42, wobei der Empfänger (154) dazu geeignet ist, einen Bitstrom zu empfangen, der eine Identität eines jeden der zugewiesenen Upstream-Nutzlastabschnitte auf dem Downstream-Kanal (f1) angibt, wobei der Bitstrom die Identität basierend auf mindestens einem Bezeichner eines Netzwerkbezeichners, eines Stationsbezeichners, eines Upstream-Nutzlastkanal-Bezeichners und eines Mini-Abschnitt-Bezeichners angibt.

50. Schaltung nach Anspruch 42, wobei der Empfänger (154) dazu geeignet ist, einen Bitstrom zu empfangen, der eine Identität der zugewiesenen Upstream-Reservierungsanforderungs-Abschnitte auf dem Downstream-Kanal (f1) angibt, wobei der Bitstrom die Identität basierend auf mindestens einem Bezeichner eines Netzwerkbezeichners, eines Stati-

onsbezeichners, eines Upstream-Kontrollkanalbezeichners und eines Mini-Abschnitt-Bezeichners angibt.

51. Schaltung nach Anspruch 50, wobei der Empfänger (154) dazu geeignet ist, einen Bitstrom zu empfangen, der jeder Station eine Meldung angibt, dass eine Kollision an einem bestimmten Reservierungsanforderungs-Abschnitt auf dem Downstream-Kanal (f1) stattgefunden hat, wobei der Bitstrom die Meldung basierend auf mindestens einem Bezeichner des Netzwerkbezeichners, des Stationsbezeichners, des Upstream-Kontrollkanalbezeichners und des Mini-Abschnitt-Bezeichners angibt.

52. Schaltung nach einem der Ansprüche 40 bis 51, wobei jeder Kanal des Downstream-Kanals (f1), des Upstream-Nutzlastkanals (f2) und des Upstream-Kontrollkanals (f3) seine eigene Mittenfrequenz, Bandbreite und Modulationsmethode aufweist.

53. Schaltung nach einem der Ansprüche 40 bis 52, wobei die Station ein Kabelmodem ist, und wobei der gemeinsame Datenträger ein Hybrid-Faser-Koaxial-Netzwerk ist.

54. Schaltung in einem zentralen Steuergerät eines Netzwerks zum Ermöglichen der Kommunikation von Bitströmen von einer Station (150) auf einem gemeinsamen Datenträger des Netzwerks, umfassend:

(a) einen ersten Empfänger (255), um aus einem Upstream-Kontrollkanal (f3) einen Reservierungsanforderungs-Bitstrom zu empfangen, der die Reservierung von Abschnitten eines Upstream-Nutzlastkanals (f2) für eine bestimmte Station (150) anfordert,
(b) einen Sender (256'), um auf einem Downstream-Kanal (f1) einen Bitstrom zu senden, der einen oder mehrere Abschnitte des Upstream-Nutzlastkanals (f2) angibt, die der bestimmten Station (150) zugewiesen sind, und
(c) einen zweiten Empfänger (254), um von einem der zugewiesenen Abschnitte eines Upstream-Nutzlastkanals (f2) einen Bitstrom zu empfangen, wobei die Schaltung **dadurch gekennzeichnet ist, dass** sie ferner umfasst:

eine vorgeschaltete Synchronisiereinrichtung, um den Sender (256') dazu zu veranlassen, auf dem Downstream-Kanal (f1) einen Bitstrom zu senden, der eine Angabe des Vorkommens einer Gruppe von verfügbaren Abschnitten in dem Upstream-Kontrollkanal (f3) enthält.

55. Schaltung nach Anspruch 54, wobei die Bitströme gleichzeitig auf dem Upstream-Kontrollkanal (f3) und dem Upstream-Nutzlastkanal (f2) des gemeinsamen Datenträgers während überlappenden Zeiträumen transportiert werden.

56. Schaltung nach Anspruch 54, ferner umfassend:

eine Kollisionserfassungsschaltung (290), um zu erfassen, ob eine Kollision in dem Reservierungsanforderungs-Bitstrom stattgefunden hat, der von dem ersten Empfänger (255) empfangen wurde, und als Antwort auf die Erfassung der Kollision, den Sender (255) dazu zu veranlassen, einen Bitstrom auf dem Downstream-Kanal (f1) zu senden, der eine Meldung für mindestens die bestimmte Station (150) enthält, dass die Kollision stattgefunden hat.

57. Schaltung nach Anspruch 54, ferner umfassend:

eine Ressourcenzuteilungseinrichtung, um auf den Reservierungsanforderungs-Bitstrom und ein Nichtvorhandensein verfügbarer Abschnitte in dem Upstream-Nutzlastkanal zu antworten, indem der Sender (256') dazu veranlasst wird, den Bitstrom auf dem Downstream-Kanal zu senden, der eine Empfangsbestätigung des Reservierungsanforderungs-Bitstroms von der bestimmten Station (150) enthält, aber auch angibt, dass derzeit keine Abschnitte des Upstream-Nutzlastkanals (f2) für die Zuteilung verfügbar sind.

58. Schaltung nach Anspruch 54, ferner umfassend:

einen Downstream-Sendedatenpuffer (240) zum Speichern eines Nutzlastbitstroms, der von dem zweiten Empfänger (254) aus dem Upstream-Nutzlastkanal (f2) empfangen wurde, der von einer ersten Station (150) ausgeht und für eine zweite Station (150) bestimmt ist, und eine vorgeschaltete Synchronisiereinrichtung, um den Sender (256') dazu zu veranlassen, den Nutzlastbitstrom auf dem Downstream-Kanal (f1) zu senden.

59. Schaltung nach einem der Ansprüche 54 bis 58, wobei jeder Kanal des Downstream-Kanals (f1), des Upstream-Nutzlastkanals (f2) und des Upstream-Kontrollkanals (f3) seine eigene Mittenfrequenz, Bandbreite und Modulationsmethode aufweist.

Revendications

1. Procédé pour permettre à un poste (150) de communiquer par l'intermédiaire d'un support partagé d'un réseau comprenant les étapes consistant à :

(a) Transmettre sur une voie montante de commandes un train binaire de demandes de réservation contenant une demande de réservation d'un ou plusieurs intervalles d'une voie montante de données utiles (f2) ;
(b) Recevoir une pluralité de trains binaires d'une voie descendante (f1), comprenant au moins un train binaire contenant une indication d'un ou plusieurs intervalles de ladite voie montante de données utiles (f2) attribués audit poste pour la transmission de trains binaires de données utiles, et
(c) Transmettre lesdits trains binaires de données utiles sur ladite voie de données utiles (f2), seulement au niveau desdits intervalles attribués de ladite voie montante de données utiles (f2); ledit procédé étant **caractérisé par le fait qu'**il comprend les autres étapes consistant à :
(d) Avant l'étape (a), attendre qu'un train binaire soit reçu de ladite voie montante (f1) indiquant l'identité d'un groupe disponible d'un ou plusieurs intervalles de réservation dans ladite voie montante de commandes (f3),
(e) Si des données sont disponibles pour être transmises dudit poste, déterminer de façon aléatoire, à partir dudit groupe disponible indiqué d'intervalles de réservation, s'il faut ou non réaliser l'étape (a), mais seulement pendant l'un desdits intervalles de réservation dudit groupe indiqué d'intervalles de réservation.

2. Procédé selon la revendication 1, dans lequel ledit train binaire de demandes de réservation et lesdits trains binaires de données utiles sont acheminés simultanément sur ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2) dudit support partagé au cours des périodes de superposition.

3. Procédé selon la revendication 1, dans lequel ledit train binaire de demandes de réservation et lesdits trains binaires de données utiles sont transmis séquentiellement en commutant entre la transmission dudit train binaire de demandes de réservation et la transmission des trains binaires de données utiles.

4. Procédé selon la revendication 2 ou la revendication 3, comprenant en outre les étapes consistant à :

(f) Après le début de réalisation de l'étape (a), recevoir de la dite voie descendante (f1) un train binaire indiquant qu'une collision a eu lieu dans ladite voie montante de commandes (f3) en réalisant ladite étape (a), et
(g) En réponse, retransmettre ledit train binaire de demandes de réservation.

5. Procédé selon la revendication 2 ou la revendication 3, comprenant en outre les étapes consistant à:

(f) Après la réalisation de l'étape (a) mais avant l'étape (b), initialiser un chronomètre d'accusé de réception, et
(g) En réponse à l'expiration du compteur d'accusé de réception avant de recevoir un train binaire contenant un accusé de réception de ladite voie descendante (f1), répéter l'étape (a).

6. Procédé selon la revendication 5 comprenant en outre les étapes consistant à:

(h) Après avoir réalisé l'étape (f), mais avant la réalisation de l'étape (g), recevoir ledit train binaire de ladite voie montante (f1) contenant un accusé de réception de ladite demande de réservation mais aussi indiquer qu'il n'y a pas d'intervalles dans ladite voie montante de données utiles qui soient disponibles pour affectation, et
(i) Se garder de répéter l'étape (a) dans ladite étape (g).

7. Procédé selon la revendication 2 ou la revendication 3, comprenant en outre l'étape consistant à :

(f) Recevoir de ladite voie descendante (f2) un train binaire de données utiles contenant un message communiqué provenant d'un autre poste dans ledit réseau.

8. Procédé selon la revendication 2 ou la revendication 3, dans lequel chacun desdits trains binaires reçus de ladite voie descendante est organisé en paquets de transport MPEG-2.

9. Procédé selon la revendication 2 ou la revendication 3, dans lequel ladite voie montante de commandes (f3), ladite voie montante de données utiles (f2) et ladite voie descendante (f1) ont une bande de fréquences mutuellement différente.

10. Procédé selon la revendication 2 ou la revendication 3, dans lequel ledit réseau est un réseau de câbles, ledit poste (150) est un poste d'abonné (150) et ledit support partagé comprend le câblage.

11. Procédé selon la revendication 2 ou la revendication 3 dans lequel ledit réseau est un réseau sans fil, ledit poste est une unité de communication et ledit support partagé est l'air.

12. Procédé selon la revendication 2 ou la revendication 3, dans lequel ledit réseau est un réseau par satellite, ledit poste est une station terrestre et ledit support partagé comprend l'air et le vide spatial.

13. Procédé selon la revendication 2 ou la revendication

3, dans lequel ladite voie descendante (f1) est reçue par une pluralité de postes par l'intermédiaire dudit support partagé.

14. Procédé selon la revendication 2 ou la revendication 3, dans lequel ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2) sont des voies d'accès multiples.

15. Procédé selon la revendication 2 ou la revendication 3, dans lequel des première et deuxième technique de modulation sont utilisées pour ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2), respectivement, ladite première technique de modulation optimisant la robustesse de ladite voie montante de commandes (f3) sans dégrader la robustesse ou l'utilisation de ladite voie montante de données utiles (f2).

16. Procédé selon la revendication 2 ou la revendication 3, dans lequel dans l'étape (a), ladite voie montante de commandes (f3) sur laquelle ledit train binaire contenant ladite demande est transmise est l'une de plusieurs voies montantes de commandes (f3).

17. Procédé selon la revendication 2 ou la revendication 3, dans lequel dans l'étape (b), ladite voie descendante (f1) sur laquelle ledit train binaire contenant ladite indication est reçue est l'une de plusieurs voies descendantes (f1).

18. Procédé selon la revendication 2 ou la revendication 3, dans lequel dans l'étape (c), ladite voie montante de données utiles (f2) sur laquelle ledit train binaire est transmis est l'une de plusieurs voies montantes de données utiles (f2).

19. Procédé selon la revendication 3 dans lequel avant l'étape (a) ; il comprend en outre l'étape consistant à recevoir un train binaire indiquant une identité dudit réseau à accès multiples de la dite voie descendante (f1), dans lequel ladite identité dudit réseau comprend au moins une identité desdites voies descendantes (f1) et montantes (f2, f3).

20. Procédé selon l'une quelconque des revendications 1 à 19, dans lequel chacune de ladite voie descendante (f1), de ladite voie montante de données utiles (f2) et de ladite voie montante de commandes (f3) a sa propre fréquence centrale, largeur de bande et son propre schéma de modulation.

21. Procédé de l'une quelconque des revendications 1 à 20, dans lequel ledit poste est un modem de câble, et dans lequel ledit support partagé est un réseau hybride coaxial à fibres.

22. Procédé selon l'une quelconque des revendications 1 à 21, dans lequel ladite voie montante de commandes (f3) est l'une d'une pluralité de voies montantes de cominandes, et dans lequel ladite voie montante de données utiles (f2) est l'une d'une pluralité de voies montantes de données utiles.

23. Procédé selon la revendication 1, dans lequel ledit réseau comprend en outre un contrôleur central, et dans lequel une communication entre ledit poste (150) et ledit contrôleur est permise en réalisant les étapes (a), (b), (c), (d) et (e).

24. Procédé selon la revendication 23, dans lequel ledit train binaire de demandes de réservation et lesdits trains binaires de données utiles sont acheminés simultanément sur ladite voie montante de commandes (f3) et sur la voie montante de données utiles (f2) dudit support partagé au cours des périodes de superposition.

25. Procédé selon la revendication 23, dans lequel ledit train binaire de demandes de réservation et lesdits trains binaires de données utiles sont transmis séquentiellement par commutation entre la transmission dudit train binaire de demandes de réservation et la transmission desdits trains binaires de données utiles.

26. Procédé dans un contrôleur central d'un réseau, pour permettre la communication de trains binaires d'un poste particulier (150) par l'intermédiaire d'un support partagé du réseau comprenant les étapes consistant à :

(a) Recevoir d'une voie montante de commandes (f3), un train binaire de demandes de réservation, demandant la réservation d'intervalles d'une voie montante de données utiles pour ledit poste particulier (150).
(b) Transmettre sur une voie descendante (f1), un train binaire indiquant un ou plusieurs intervalles de ladite voie de données utiles attribués audit poste particulier (150), et
(c) Recevoir un train binaire dudit poste particulier (150) d'un ou plusieurs intervalles attribués d'une voie montante de données utiles (f_2) ; ledit procédé étant **caractérisé par le fait qu'**il comprend en outre les étapes consistant à :
(d) Avant l'étape (a), transmettre sur ladite voie descendante (f1) un train binaire comprenant l'indication d'une occurrence d'un groupe d'un ou plusieurs intervalles sur ladite voie montante de commandes (f3).

27. Procédé selon la revendication 26, dans lequel ledit train binaire de demandes de réservation et lesdits trains binaires de données utiles sont acheminés simultanément sur ladite voie montante de comman-

des (f3) et ladite voie montante de données utiles (f2) dudit support partagé pendant les périodes de superposition.

28. Procédé selon la revendication 26, dans lequel ledit train binaire de demandes de réservation et lesdits trains binaires de données utiles sont acheminés séquentiellement par commutation entre la transmission dudit train binaire de demandes de réservation et la transmission des trains binaires de données utiles.

29. Procédé selon la revendication 27 ou de la revendication 28 comprenant en outre les étapes consistant à:

(e) Détecter une collision au cours de ladite étape (a), et
(f) En réponse à ladite collision, transmettre un train binaire dans ladite voie de données utiles comprenant une notification au moins au poste particulier (150) que ladite collision a eu lieu.

30. Procédé selon la revendication 27 ou la revendication 28 comprenant en outre les étapes consistant à:

(e) Après l'étape (a) mais avant l'étape (b), en réponse à une absence d'intervalles disponibles dans ladite voie montante de données utiles (f2), transmettre ledit train binaire sur ladite voie descendante comprenant un accusé de réception de ladite demande de réservation dudit poste particulier (150) mais comprenant également une indication selon laquelle aucun intervalle de ladite voie montante de données utiles (f2) n'est actuellement disponible pour affectation.

31. Procédé selon la revendication 27 ou la revendication 28 comprenant en outre les étapes consistant à:

(e) Recevoir un train binaire de données utiles de ladite voie montante de données utiles provenant d'un premier poste (150) et pour un deuxième poste (150), et
(f) Transmettre ledit train binaire de données utiles sur ladite voie descendante (f1).

32. Procédé selon la revendication 27 ou la revendication 28 dans lequel ladite voie montante de commandes (f3), ladite voie montante de données utiles (f2) et ladite voie descendante (f1) ont chacune mutuellement une bande de fréquences différente.

33. Procédé selon la revendication 27 ou la revendication 28 dans lequel ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2) sont des voies à accès multiples.

34. Procédé selon la revendication 27 ou la revendication 28 dans lequel ladite voie descendante (f1) est reçue par une pluralité de postes par l'intermédiaire dudit support partagé.

35. Procédé selon la revendication 28, dans lequel à l'étape (b), chacun des intervalles de temps attribués étant indiqué par au moins un identifiant du réseau, un identifiant du poste, un identifiant de la voie montante de données utiles et un identifiant du mini-intervalle

36. Procédé selon la revendication 28, dans lequel à l'étape (d), chacun des intervalles de temps étant indiqué par au moins un parmi l'identifiant du réseau, l'identifiant du poste, l'identifiant d'une voie montante de commandes et l'identifiant d'un mini-intervalle.

37. Procédé selon la revendication 27, dans lequel des première et deuxième techniques de modulation sont utilisées pour ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2), respectivement, ladite première technique de modulation optimisant la robustesse de ladite voie montante de commandes sans dégrader de robustesse ou l'utilisation de ladite voie montante de données utiles (f2).

38. Procédé selon l'une quelconque des revendications 26 à 37, dans lequel chacune de ladite voie descendante (f1), de ladite voie montante de données utiles (f2) et de ladite voie montante de commandes (f3) a sa propre fréquence centrale, sa propre largeur de bande et son propre schéma de modulation.

39. Procédé selon l'une quelconque des revendications 26 à 38, dans lequel ladite voie montante de commandes (f3) est l'une d'une pluralité de voies montantes de commandes, et dans lequel la dite voie montante de données utiles (f2) est l'une d'une pluralité de voies montantes de données utiles.

40. Circuit pour permettre à un poste (150) de communiquer par l'intermédiaire d'un support partagé d'un réseau comprenant :

(a) Un récepteur (154) pour recevoir une pluralité de trains binaires d'une voie descendante (f1), comprenant au moins un train binaire contenant une indication d'un ou plusieurs intervalles de temps d'une voie montante de données utiles attribués audit poste (150) pour transmettre les trains binaires.
(b) Des moyens de transmission (156, 356) destinés à transmettre des trains binaires de données utiles sur ladite voie de données utiles (f2), seulement au niveau desdits intervalles de temps attribués de ladite voie montante de don-

nées utiles (f2) et destinés à transmettre sur une voie montante de commandes (f3) des trains binaires de demandes de réservation d'un ou plusieurs intervalles d'une voie montante de données utiles (f2), ledit circuit étant **caractérisé par** le fait de comprendre en outre :

(c) Un planificateur de transmissions (168) pour attendre que ledit récepteur (154) reçoive un train binaire de ladite voie descendante (f1) indiquant l'identité d'un groupe disponible d'un ou plusieurs intervalles de réservation dans ladite voie montante de commandes (f3), et si les données sont disponibles pour transmission dudit poste, déterminer de manière aléatoire, à partir dudit groupe disponible d'intervalles de réservation, s'il est fait que ledit moyen de transmission (156, 356) transmette ou non ledit train binaire de demandes de réservation sur ladite voie montante de commandes (f3), mais seulement pendant l'un desdits intervalles de réservation dudit groupe d'intervalles de réservation.

41. Circuit selon la revendication 40, dans lequel ledit moyen de transmission (156) comprend un premier émetteur (178) pour transmettre lesdits trains binaires de demandes de réservation et un deuxième émetteur (184) pour transmettre lesdits trains binaires de données utiles simultanément sur ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2) dudit support partagé au cours des périodes de superposition.

42. Circuit selon la revendication 40, dans lequel ledit moyen de transmission (156) comprend émetteur (390), et dans lequel ledit circuit comprend un premier commutateur (310) pour coupler ledit émetteur (390) à l'un desdits train binaire de données utiles et train binaire de demandes de réservation, à partir d'une sélection en amont.

43. Circuit selon la revendication 40, comprenant en outre un deuxième commutateur (315) pour coupler un signal de sélection de la fréquence porteuse des données utiles audit émetteur lorsque ledit premier commutateur (310) couple ladite voie montante de données utiles (f2) audit émetteur (390) et pour coupler un signal de sélection de la fréquence porteuse de commandes audit émetteur (390) lorsque ledit premier commutateur (310) couple ladite voie montante de commandes (f3) audit émetteur.

44. Circuit selon la revendication 41 ou la revendication 42, comprenant en outre :

un circuit de décisions suivant des règles de retransmission, destiné à répondre audit récepteur recevant de ladite voie descendante (f1) un train binaire contenant une indication selon laquelle une collision a eu lieu dans ladite voie montante de commandes (f3) en faisant transmettre de nouveau audit moyen de transmission (156, 356) ledit train binaire de demandes de réservation sur ladite voie montante de commandes (f3).

45. Circuit selon la revendication 41 ou la revendication 42, comprenant en outre :

un circuit de décisions suivant des règles de retransmission pour initialiser un chronomètre d'accusé de réception, après transmission par ledit moyen de transmission (156, 356) du train binaire de demandes de réservation sur ladite voie montante de commandes (f3) et, en réponse au chronomètre d'accusé de réception expirant avant réception par ledit récepteur (154) d'un train binaire contenant un accusé de réception issu de ladite voie descendante (f1), faisant en sorte que le moyen de transmission (156, 356) transmette de nouveau ledit train binaire de demandes de réservation sur ladite voie montante de commande (f3).

46. Circuit selon la revendication 45, dans lequel après initialisation dudit chronomètre, mais avant que ledit chronomètre expire, ledit récepteur (154) reçoit un train binaire de ladite voie descendante (f1) contenant un accusé de réception dudit train binaire de demandes de réservation mais contenant également une indication selon laquelle il n'y a pas d'intervalles disponibles dans la dite voie montante de données utiles (f2) pour l'affectation, et dans lequel, en réponse, ledit circuit de décisions suivant des règles de retransmission retient ledit moyen de transmission (156, 356) de retransmettre ledit train binaire de demandes de réservation sur la dite voie montante de commandes (f3).

47. Circuit selon la revendication 41 ou de la revendication 42, dans lequel le récepteur (154) est adapté pour recevoir de ladite voie descendante (f1) un train binaire de données utiles contenant un message communiqué provenant d'un autre poste (150) dans ledit réseau.

48. Circuit selon la revendication 42, dans lequel le récepteur (154) est adapté pour recevoir un train binaire indiquant une identité dudit réseau à accès multiples sur ladite voie descendante (f1), dans laquelle ladite identité dudit réseau comprend au moins une identité desdites voies descendantes (f1) et montantes (f2, f3).

49. Circuit selon la revendication 42, dans lequel le récepteur (154) est adapté pour recevoir un train binaire indiquant une identité de chacun des interval-

les montants attribués en amont sur ladite voie descendante (f1), ledit train binaire indiquant ladite identité à partir d'au moins un parmi l'identifiant d'un réseau, l'identifiant d'un poste, l'identifiant d'une voie montante de données utiles et l'identifiant d'un mini-intervalle.

50. Circuit selon la revendication 42, dans lequel le récepteur (154) est adapté pour recevoir un train binaire indiquant une identité d'intervalles montants de demandes de réservation attribués en amont sur ladite voie descendante (f1), ledit train binaire indiquant ladite identité à partir d'au moins un parmi l'identifiant d'un réseau, l'identifiant d'un poste, l'identifiant d'une voie montante de commandes et l'identifiant d'un mini-intervalle.

51. Circuit selon la revendication 50, dans lequel le récepteur (154) est adapté pour recevoir un train binaire indiquant une notification à chaque poste selon laquelle une collision a eu lieu au niveau d'un intervalle particulier de demande de réservation sur ladite voie descendante (f1), ledit train binaire indiquant ladite notification à partir d'un au moins parmi ledit identifiant de réseau, ledit identifiant de poste, ledit identifiant de voie montante de commandes et ledit identifiant de mini-intervalle.

52. Circuit selon l'une quelconque des revendications 40 à 51, dans lequel chacune de ladite voie descendante (f1), ladite voie montante de données utiles (f2) et ladite voie montante de commandes (f3) a sa propre fréquence centrale, largeur de bande et son propre schéma de modulation.

53. Circuit selon l'une quelconque des revendications 40à 52, dans lequel ledit poste est un modem de câble, et dans lequel ledit support partagé est un réseau hybride coaxial à fibres.

54. Circuit dans un contrôleur central d'un réseau, pour permettre la communication de trains binaires à partir d'un poste (150) sur un support partagé du réseau comprenant:

(a) Un premier récepteur (255) pour recevoir d'une voie montante de commandes (f3) un train binaire de demandes de réservation, demandant la réservation d'intervalles d'une voie montante de données utiles (f2) pour un poste particulier (150),
(b) Un émetteur (256') pour transmettre sur une voie descendante (f1), un train binaire indiquant un ou plusieurs intervalles de ladite voie montante de données utiles attribués audit poste particulier (150), et
(c) Un deuxième récepteur (254) pour recevoir ledit train binaire de l'un desdits intervalles attribués d'une voie montante de données utiles (f2), ledit circuit

étant **caractérisé par le fait qu'**il comprend en outre :

Un synchroniseur amont destiné à faire transmettre par ledit émetteur (256') sur une voie descendante (f1) un train binaire contenant une indication de l'occurrence d'un groupe d'intervalles disponibles dans ladite voie montante de commandes (f3).

55. Circuit selon la revendication 54, dans lequel lesdits trains binaires sont acheminés simultanément sur ladite voie montante de commandes (f3) et ladite voie montante de données utiles (f2) dudit support partagé au cours des périodes de superposition.

56. Circuit selon la revendication 54, comprenant en outre:

un circuit de détection de collisions (290) pour détecter si oui ou non une collision a eu lieu dans ledit train binaire de demandes de réservation reçu par ledit premier récepteur (255), et en réponse à la détection de ladite collision, faire transmettre par ledit émetteur (255) un train binaire sur ladite voie descendante (f1) contenant une notification au moins audit poste particulier (150) qu'une collision a eu lieu.

57. Circuit selon la revendication 54, comprenant en outre:

un dispositif d'affectation de ressources destiné à répondre audit train binaire de demandes de réservation et à une absence d'intervalles disponibles dans ladite voie montante de données utiles, en faisant en sorte que ledit émetteur (256') transmette ledit train binaire sur ladite voie descendante contenant an accusé de réception dudit train binaire de demandes de réservation dudit poste particulier (150), mais indiquant également qu'il n'y a pas d'intervalles de ladite voie montante de données utiles (f2) actuellement disponibles pour affectation.

58. Circuit selon la revendication 54, comprenant en outre :

une mémoire tampon de données de transmission descendante (240) destinée à mémoriser un train binaire de données utiles reçu par ledit deuxième récepteur (254) de ladite voie montante de données utiles (f2) provenant d'un premier poste (150) et destinée à un deuxième poste (150), et un synchroniseur amont pour faire

transmettre par ledit émetteur (256) ledit train binaire de données utiles sur ladite voie descendante (f1):

59. Circuit selon l'une quelconque des revendications 54 à 58, dans lequel chacune de ladite voie descendante (f1), de ladite voie montante de données utiles (f2) et de ladite voie montante de commandes (f3) a sa propre fréquence centrale, sa propre largeur de bande et son propre schéma de modulation.

FIG. 1
(PRIOR ART)

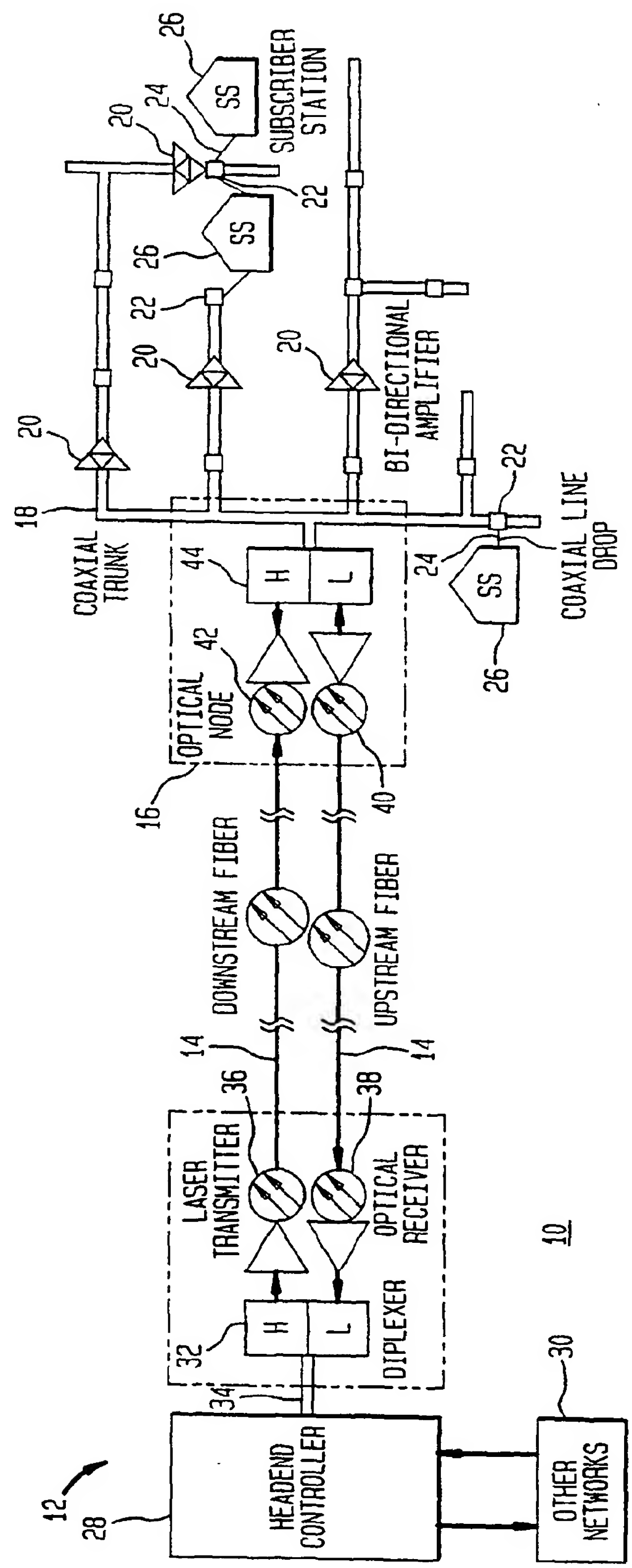


FIG. 2
(PRIOR ART)

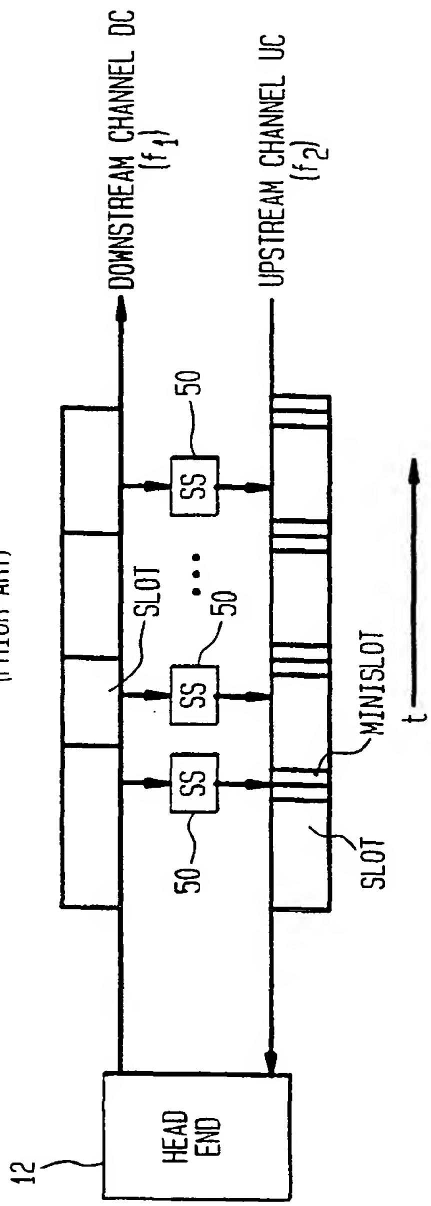


FIG. 3
(PRIOR ART)

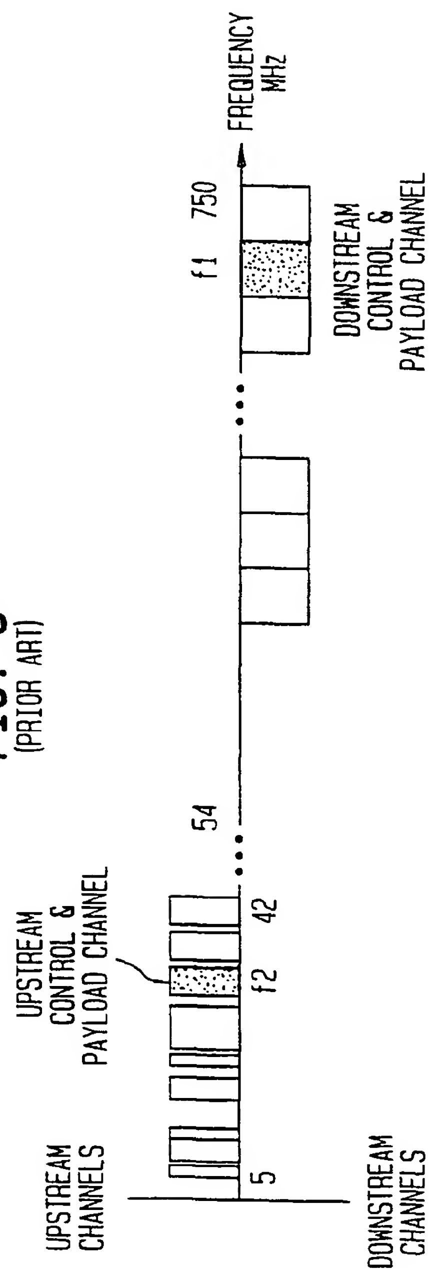


FIG. 4
(PRIOR ART)

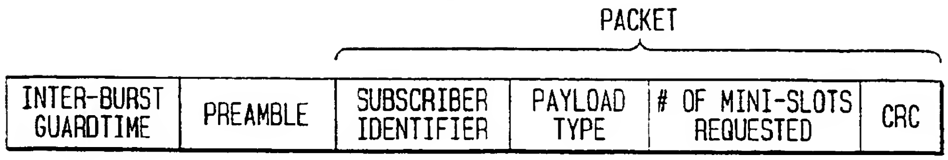


FIG. 5
(PRIOR ART)

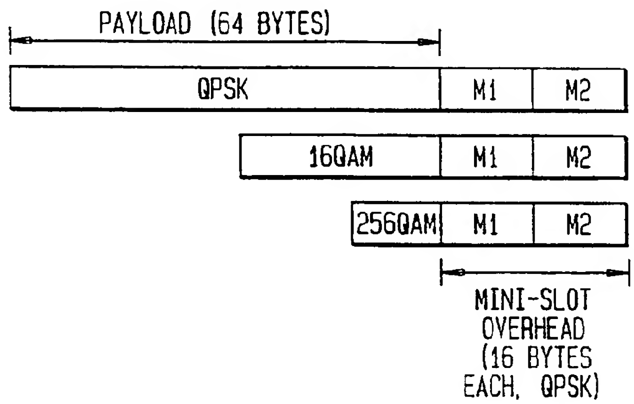


FIG. 6
(PRIOR ART)

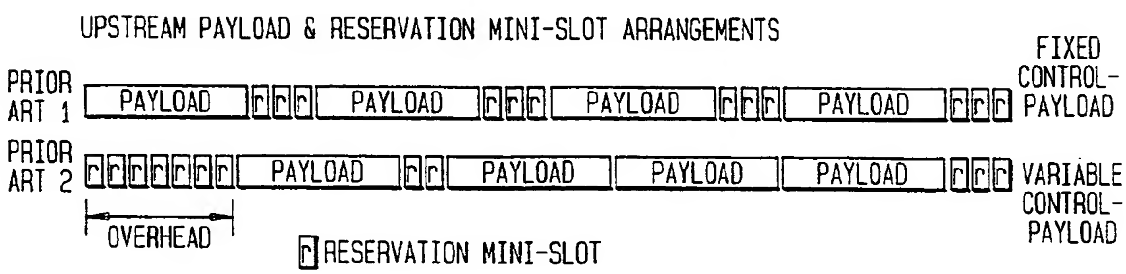


FIG. 7

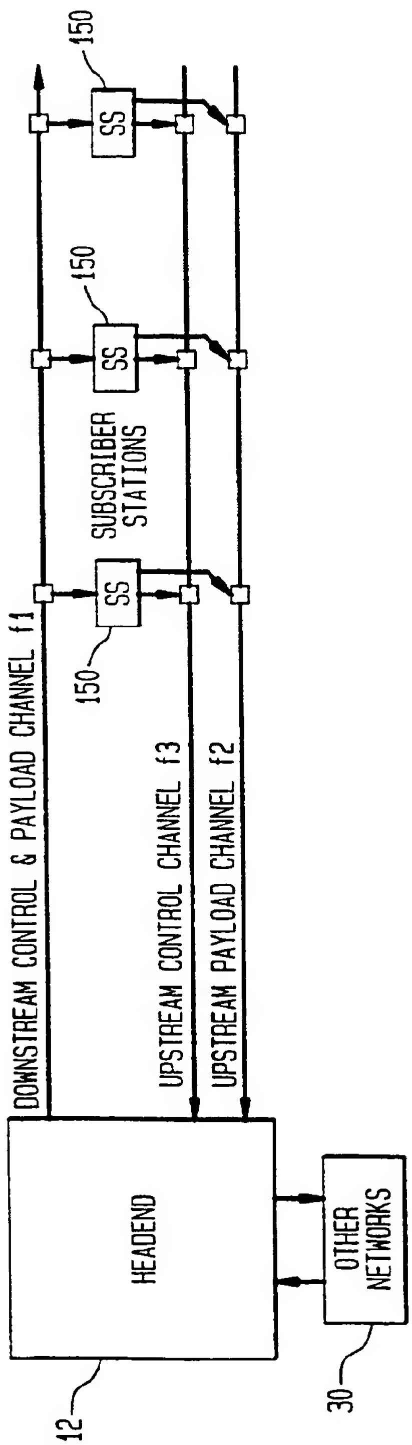


FIG. 8

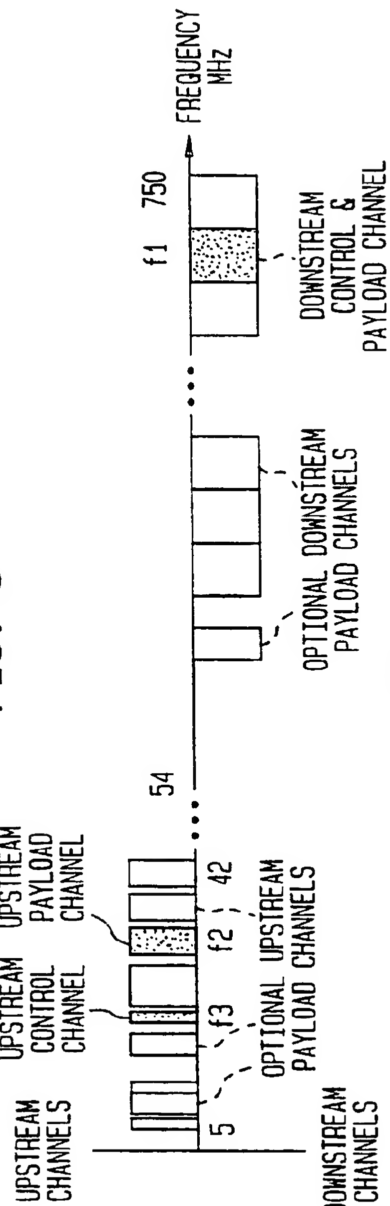


FIG. 9

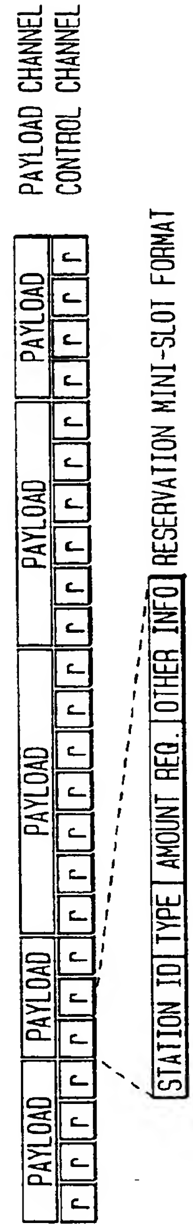


FIG. 10A

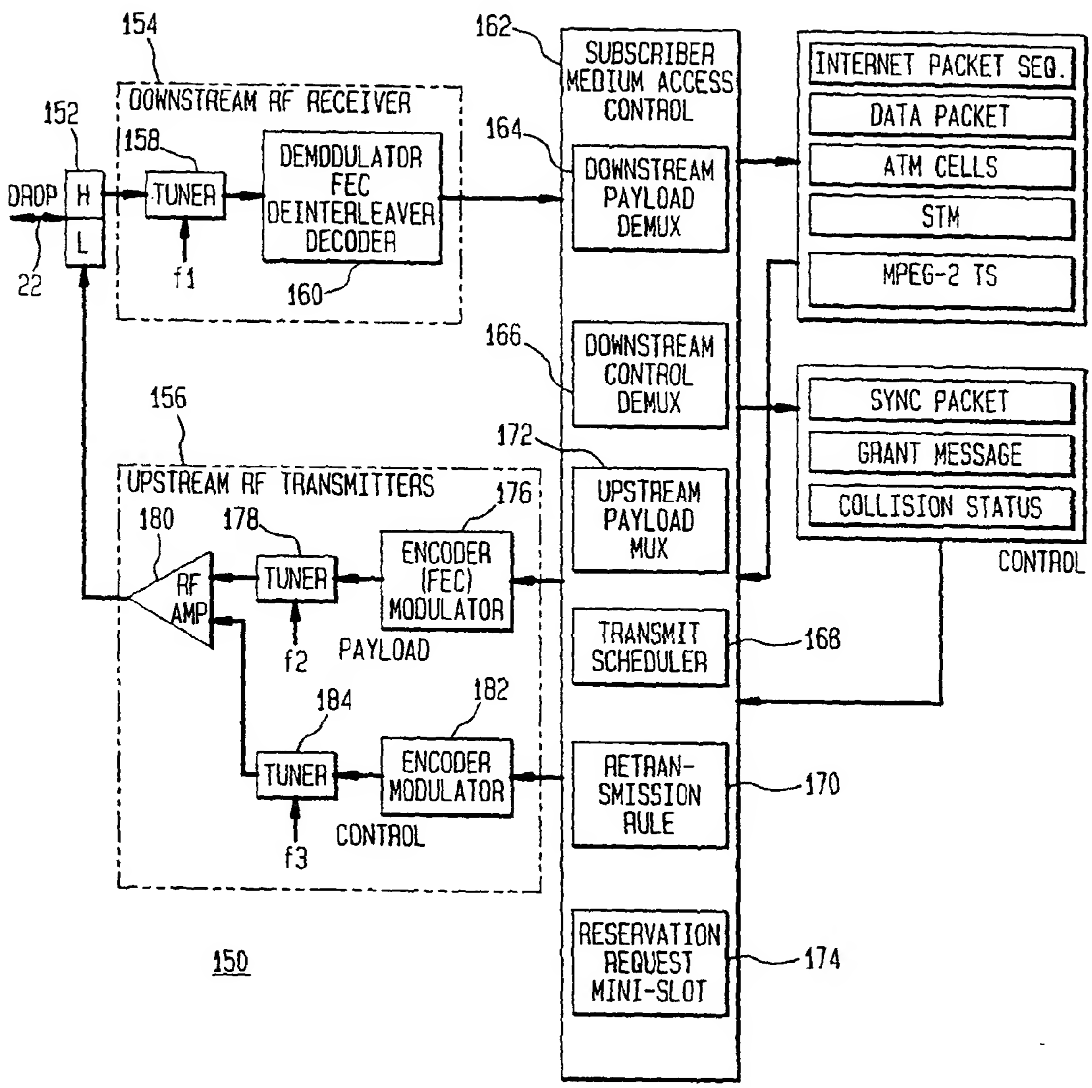

154
162
SUBSCRIBER MEDIUM ACCESS CONTROL
INTERNET PACKET SEQ.
DATA PACKET
ATM CELLS
STM
MPEG-2 TS
DOWNSTREAM RF RECEIVER
152
158
DEMODULATOR FEC DEINTERLEAVER DECODER
164
DOWNSTREAM PAYLOAD DEMUX
DROP
H
L
TUNER
f1
22
160
166
DOWNSTREAM CONTROL DEMUX
SYNC PACKET
GRANT MESSAGE
COLLISION STATUS
156
172
UPSTREAM RF TRANSMITTERS
176
UPSTREAM PAYLOAD MUX
CONTROL
180
178
RF AMP
TUNER
ENCODER (FEC) MODULATOR
f2
PAYLOAD
TRANSMIT SCHEDULER
168
184
182
TUNER
ENCODER MODULATOR
RETRAN-SMISSION RULE
170
f3
CONTROL
RESERVATION REQUEST MINI-SLOT
174
150

FIG. 10B

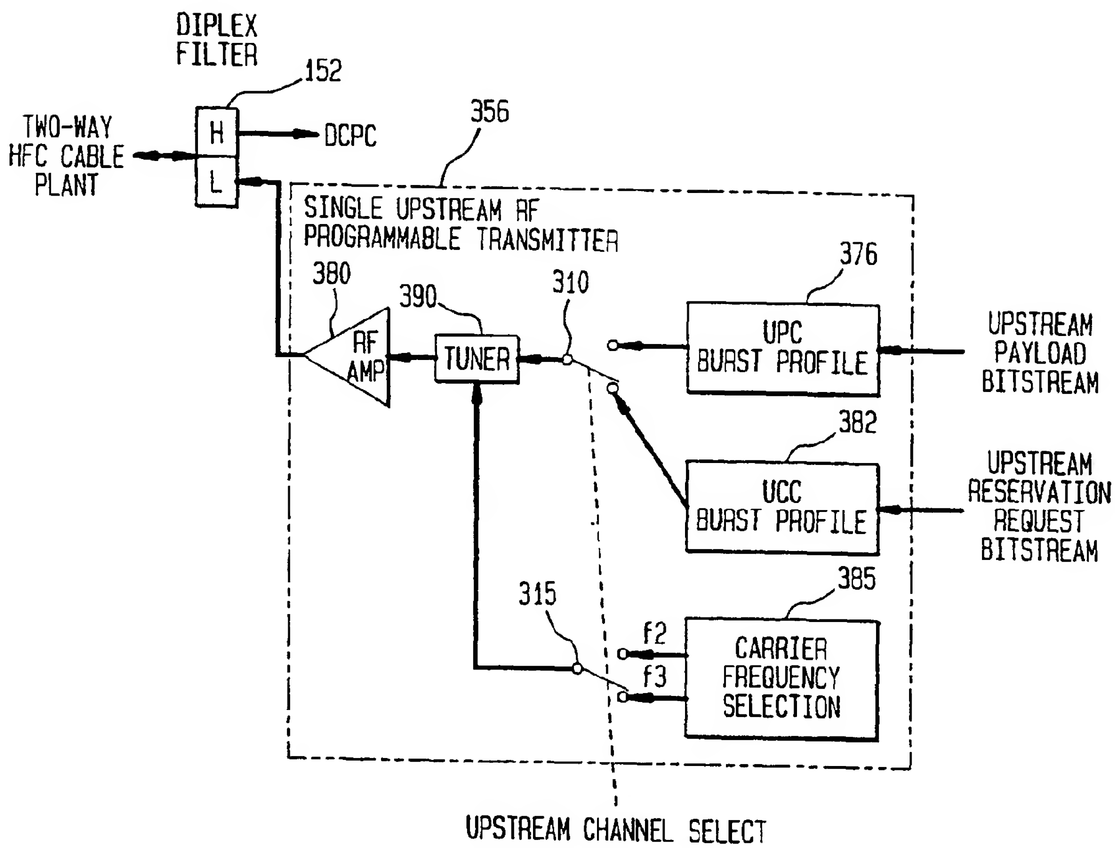

DIPLEX
FILTER
152
TWO-WAY
HFC CABLE
PLANT
H
L
DCPC
356
SINGLE UPSTREAM RF
PROGRAMMABLE TRANSMITTER
376
380
390
310
RF
AMP
TUNER
UPC
BURST PROFILE
UPSTREAM
PAYLOAD
BITSTREAM
382
UCC
BURST PROFILE
UPSTREAM
RESERVATION
REQUEST
BITSTREAM
385
315
f2
f3
CARRIER
FREQUENCY
SELECTION
UPSTREAM CHANNEL SELECT

FIG. 11

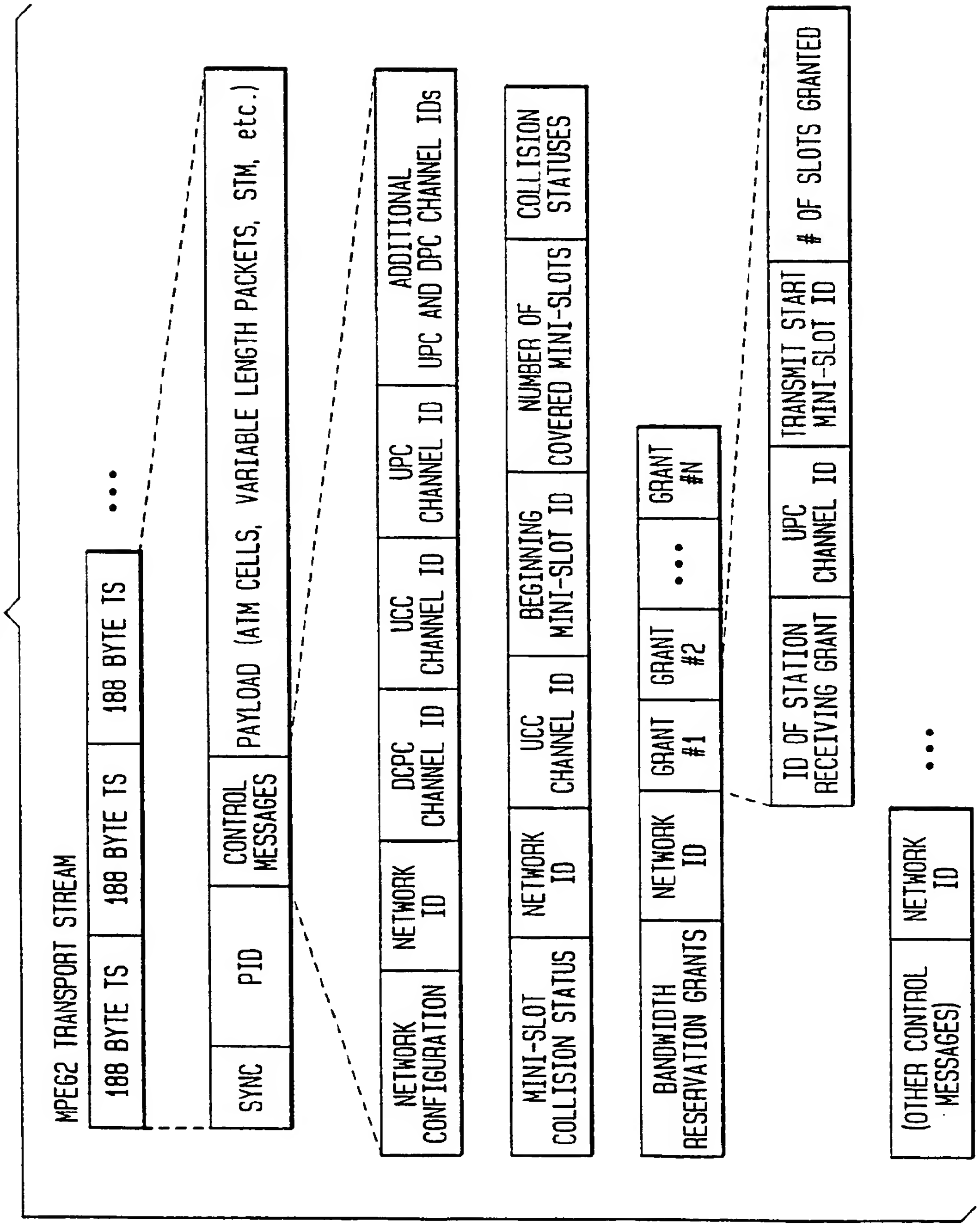

MPEG2 TRANSPORT STREAM
188 BYTE TS
188 BYTE TS
188 BYTE TS
SYNC
PID
CONTROL MESSAGES
PAYLOAD (ATM CELLS, VARIABLE LENGTH PACKETS, STM, etc.)
NETWORK CONFIGURATION
NETWORK ID
DCPC CHANNEL ID
UCC CHANNEL ID
UPC CHANNEL ID
ADDITIONAL UPC AND DPC CHANNEL IDs
MINI-SLOT COLLISION STATUS
NETWORK ID
UCC CHANNEL ID
BEGINNING MINI-SLOT ID
NUMBER OF COVERED MINI-SLOTS
COLLISION STATUSES
BANDWIDTH RESERVATION GRANTS
NETWORK ID
GRANT #1
GRANT #2
GRANT #N
ID OF STATION RECEIVING GRANT
UPC CHANNEL ID
TRANSMIT START MINI-SLOT ID
OF SLOTS GRANTED
(OTHER CONTROL MESSAGES)
NETWORK ID

FIG. 12

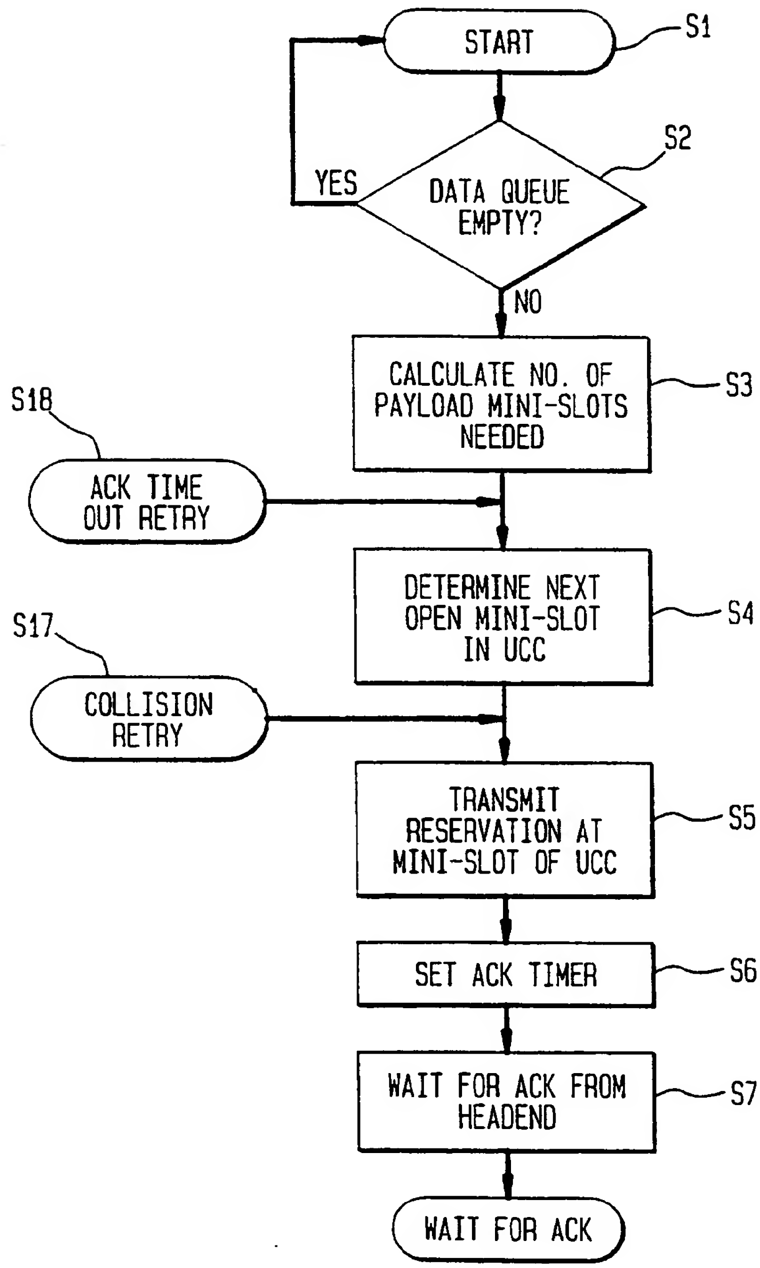

START
S1
YES
DATA QUEUE EMPTY?
S2
NO
CALCULATE NO. OF PAYLOAD MINI-SLOTS NEEDED
S3
S18
ACK TIME OUT RETRY
DETERMINE NEXT OPEN MINI-SLOT IN UCC
S4
S17
COLLISION RETRY
TRANSMIT RESERVATION AT MINI-SLOT OF UCC
S5
SET ACK TIMER
S6
WAIT FOR ACK FROM HEADEND
S7
WAIT FOR ACK

FIG. 13

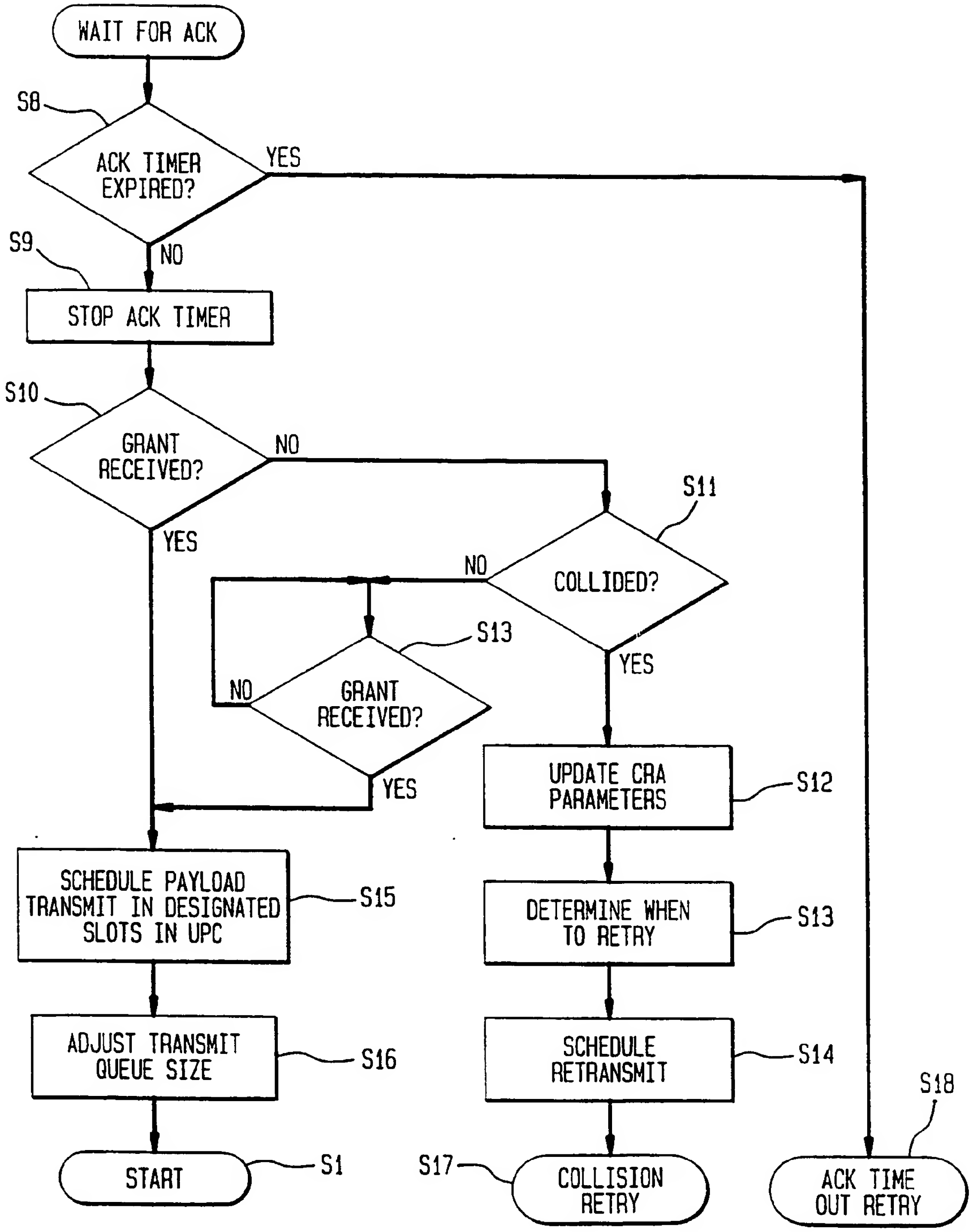

WAIT FOR ACK
S8
ACK TIMER EXPIRED?
YES
NO
S9
STOP ACK TIMER
S10
GRANT RECEIVED?
NO
YES
S11
COLLIDED?
NO
YES
S13
GRANT RECEIVED?
NO
YES
UPDATE CRA PARAMETERS
S12
SCHEDULE PAYLOAD TRANSMIT IN DESIGNATED SLOTS IN UPC
S15
DETERMINE WHEN TO RETRY
S13
ADJUST TRANSMIT QUEUE SIZE
S16
SCHEDULE RETRANSMIT
S14
S18
START
S1
S17
COLLISION RETRY
ACK TIME OUT RETRY

FIG. 14

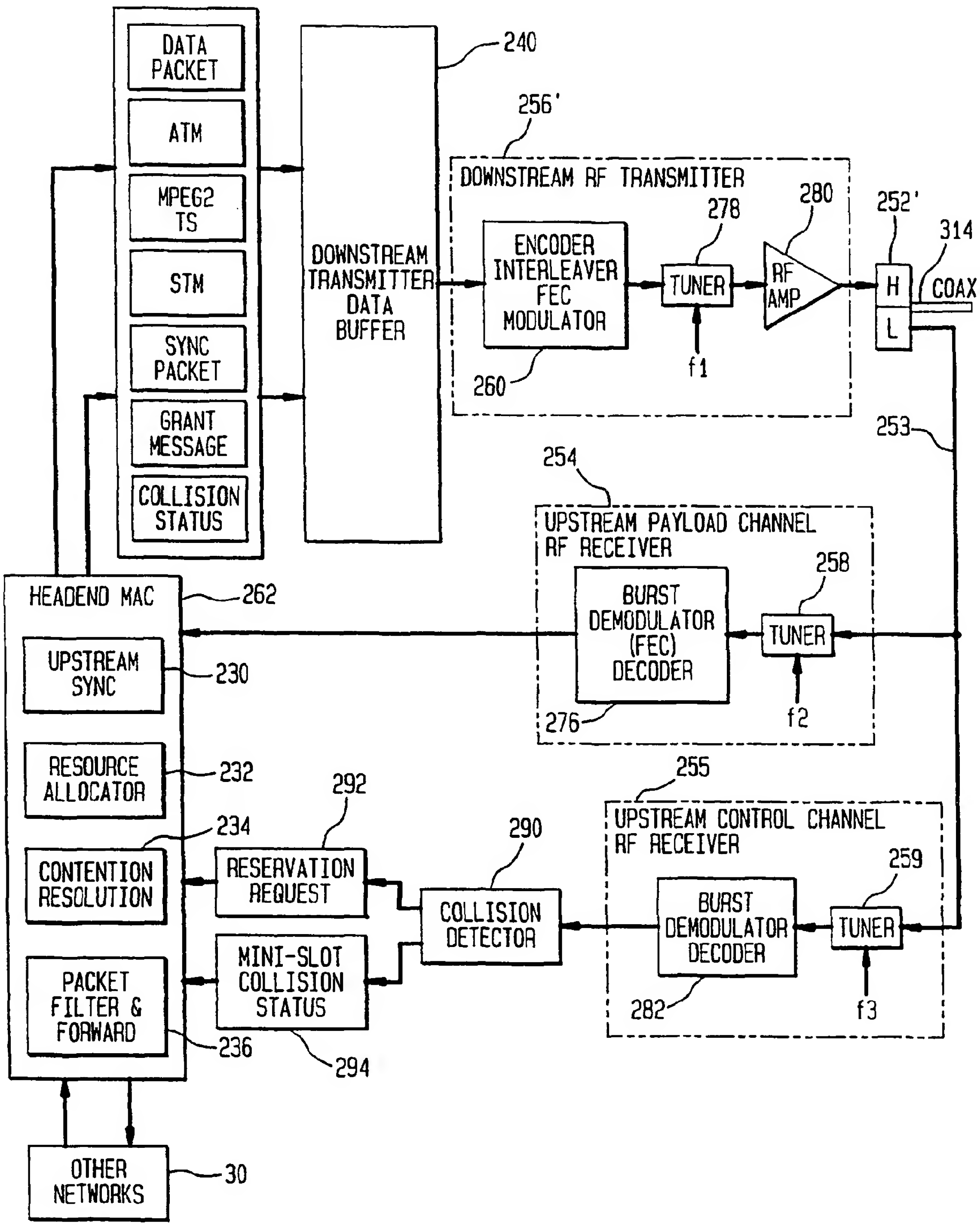

DATA PACKET
ATM
MPEG2 TS
STM
SYNC PACKET
GRANT MESSAGE
COLLISION STATUS
DOWNSTREAM TRANSMITTER DATA BUFFER
240
256'
DOWNSTREAM RF TRANSMITTER
ENCODER INTERLEAVER FEC MODULATOR
278
280
TUNER
RF AMP
f1
260
252'
314
H
L
COAX
253
254
UPSTREAM PAYLOAD CHANNEL RF RECEIVER
258
BURST DEMODULATOR (FEC) DECODER
TUNER
f2
276
HEADEND MAC
262
UPSTREAM SYNC
230
RESOURCE ALLOCATOR
232
234
CONTENTION RESOLUTION
PACKET FILTER & FORWARD
236
292
RESERVATION REQUEST
MINI-SLOT COLLISION STATUS
294
290
COLLISION DETECTOR
255
UPSTREAM CONTROL CHANNEL RF RECEIVER
259
BURST DEMODULATOR DECODER
TUNER
f3
282
OTHER NETWORKS
30

FIG. 15

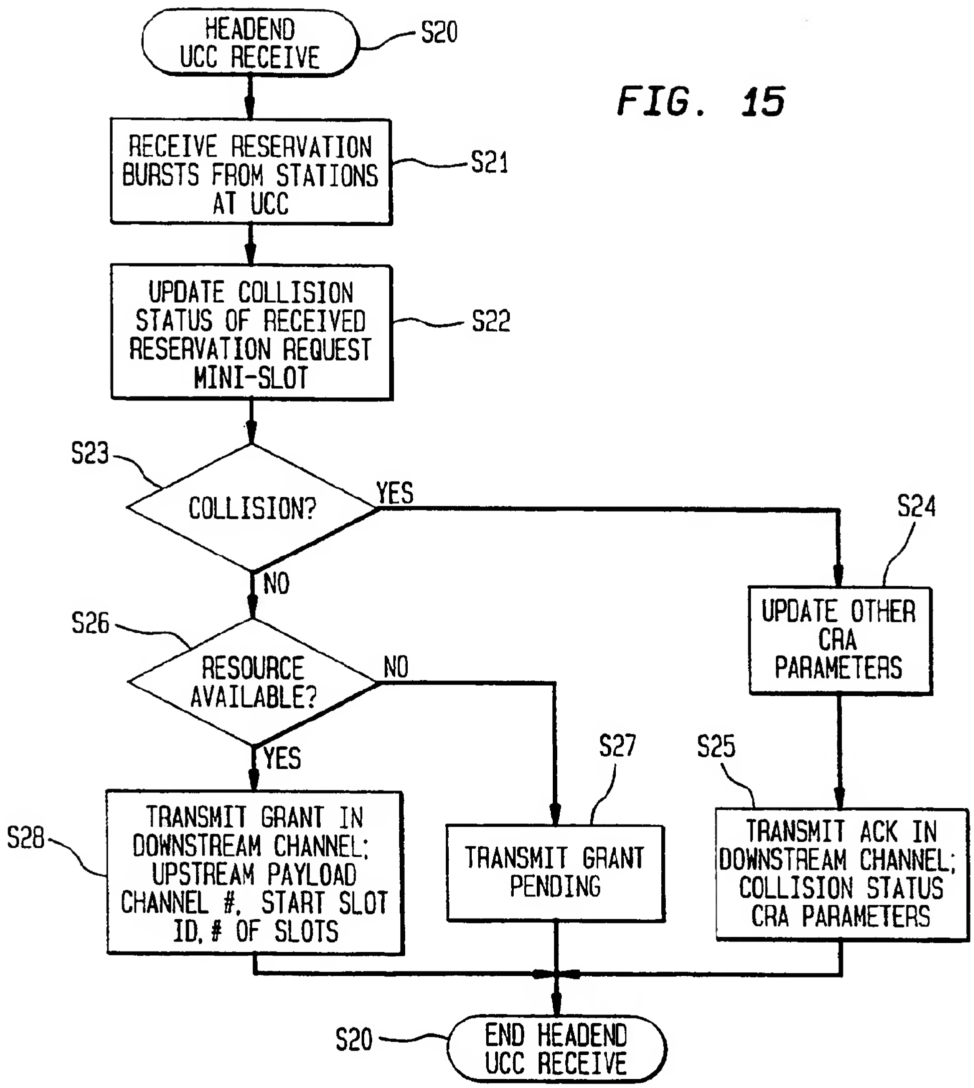
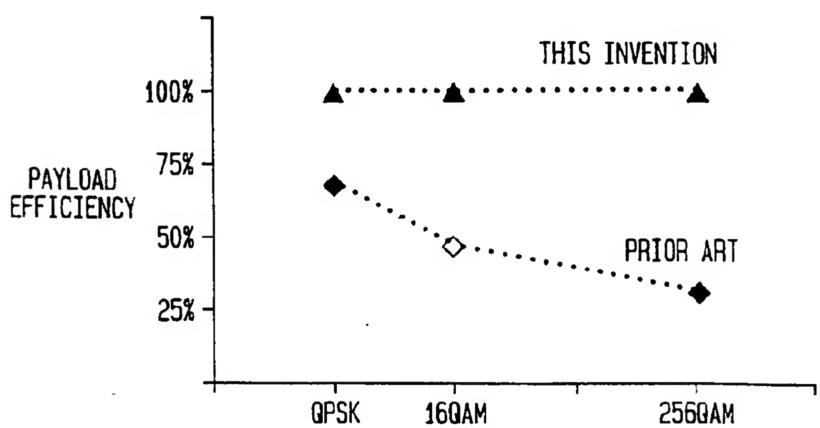

HEADEND UCC RECEIVE
S20
RECEIVE RESERVATION BURSTS FROM STATIONS AT UCC
S21
UPDATE COLLISION STATUS OF RECEIVED RESERVATION REQUEST MINI-SLOT
S22
S23
COLLISION?
YES
NO
S24
UPDATE OTHER CRA PARAMETERS
S26
RESOURCE AVAILABLE?
NO
YES
S27
S25
S28
TRANSMIT GRANT IN DOWNSTREAM CHANNEL; UPSTREAM PAYLOAD CHANNEL #, START SLOT ID, # OF SLOTS
TRANSMIT GRANT PENDING
TRANSMIT ACK IN DOWNSTREAM CHANNEL; COLLISION STATUS CRA PARAMETERS
S20
END HEADEND UCC RECEIVE

FIG. 16


THIS INVENTION
100%
75%
PAYLOAD EFFICIENCY
50%
PRIOR ART
25%
QPSK
16QAM
256QAM